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# THE IRON-FOUNDER:

## A COMPREHENSIVE TREATISE ON THE ART OF MOULDING.

INCLUDING CHAPTERS ON

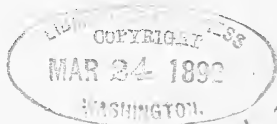
CORE-MAKING; LOAM, DRY-SAND, AND GREEN-SAND MOULDING;  
ALSO CRYSTALLIZATION, SHRINKAGE, AND CONTRACTION OF  
CAST-IRON, AND A FULL EXPLANATION OF THE SCIENCE  
OF PRESSURES IN MOULDS; ADDED TO WHICH ARE  
FORMULAS FOR MIXTURES OF IRON, TABLES,  
RULES, AND MISCELLANEOUS INFOR-  
MATION.

BY

SIMPSON BOLLAND,

*Practical Moulder and Manager of Foundries.*

Illustrated with over Three Hundred Engravings.



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## PREFACE.

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IN writing this book the principal object of the author has always been to help such of his fellow-craftsmen as, by force of circumstances, have been shut out from the wider experience which it has been his good fortune to enjoy.

It is not supposed that because a man is ignorant of certain truths connected with his trade or profession, that he is desirous of always remaining in that condition; but it must be conceded that very few of us care to confess our ignorance openly, and accept the teachings of those with whom we have been in daily contact, and for whose ability we have entertained only common respect, without question or subsequent investigation.

No man cares to parade his ignorance who feels within himself a consciousness of ability, if only the opportunity for improvement were offered him; and hundreds of men in our foundries to-day are earnestly looking for the means which shall lift them to a higher plane of usefulness, as well as establish within themselves a greater degree of self-respect.

It will be a source of great satisfaction to the author if the advent of this book should be a help to such.

As the title indicates, the subjects treated are numerous and interesting, especially to moulders; in fact this may be considered as a moulder's book, inasmuch as its pages are

devoted almost exclusively to such things as perplex the moulder in his every-day experience.

Care has been taken both in detailed description and profuse illustration to make everything plain to the reader, and the choice of subjects for illustration has been made with the view of bringing out the best and most correct ideas of moulding.

It is hoped that the subject of Crystallization, herein treated in mere outline only, will interest the reader sufficiently to cause still further investigation in that important branch of science.

The author hopes that the chapter on Pressures will, in some measure at least, help to dispel the mystery which has hitherto surrounded that subject, and thinks that the table appended will be appreciated by such as do not care to study the whole subject as presented.

When it is remembered that cupolas, ladles, cranes, and all appliances for transmission of power, are in the hands of specialists who might in a majority of cases furnish a better article at less cost, with all the necessary formulæ for their successful working, the author judges it would have been unwise to admit the discussion of such subjects in these pages, to the exclusion of topics of far greater interest to the moulder.

The tables, some of which are original, will be found useful in daily practice, and much time usually required for calculation will be saved by consulting them.

SIMPSON BOLLAND.

NEW YORK.

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# THE IRON-FOUNDER.

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## PART I.

### *INTRODUCTION.*

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#### MOULDERS: PAST, PRESENT, AND FUTURE.

WE often see in the "want" columns of our trade journals and newspapers where some young man advertises himself as not only being capable in all respects to fill the position he seeks, but backs up the application by saying that he holds a certificate of competency granted by one or other of the great schools of technology.

Very frequently this young aspirant is sneered at by our so-called "practical fellows," who, I am sorry to say, are only too ready to condemn all such who have had the courage to step out of the beaten tracks in the honest effort to thoroughly master their trade in theory as well as in practice.

Let us look for a moment at the course this young man has pursued to obtain his certificate, after which we will compare him with some of his detractors.

In the first place he had a sensible father, who every day suffered more or less on account of the lack of education.

This father, although an excellent workman, as things go, had been unable to get beyond the front rank of journeymanship from the fact that, like hundreds of others, he was unable to give a reason for what he was doing to effect certain results in the foundry; and oh ! how many times had he seen men preferred above himself all because of the "bit of book learning" which they possessed in conjunction with the natural talents shared in common with himself.

Smarting from this, he determines that his son, *who has been duly apprenticed to the trade*, shall have full opportunity to develop into a good man as well as a good mechanic, and so proceeds to surround him with good influences, excites his ambition, and encourages him in all legitimate means to obtain the desired end.

He enters him on the rolls of the nearest institution of learning, technological or otherwise, where at evenings he at once begins a course of study which will enable him to understand his trade in all its bearings; and as this mode of procedure is productive of increased zeal, every day sees the foundation of a useful career growing at a pace which before had seemed impossible of realization. For it must be remembered, that as the boy increases in knowledge his ambition to excel kindles to the heat which will keep him constant to his studies, insuring success in the end.

This, then, is the young man who possesses the certificate, and where is the sense or reason in sneering at him ?

We will inquire into the difference between him and such shopmates as have not qualified in the lines of thought pursued by the former.

Firstly, his acquired knowledge enables him to determine the nature of the materials he works with, and by a careful analysis of such before using insures a measure of success to which the uneducated is a stranger.

Secondly, the foundry furnishes abundant opportunity

for the practical demonstration of the almost numberless theories in natural philosophy, and of exploding also the several so-called mysteries which have gathered around the business of founding owing to the ignorance of the past.

And what an advantage our educated young man has over his fellows!—for, knowing absolutely what will result from certain modes of procedure, he can easily avoid all errors, and thus secure distinction and recognition; for it must be conceded that if the intelligence of the moulder measured up to the magnitude of the job he undertakes to do, barring accident, he would never fail in its successful accomplishment.

Instead of sneering at the refined young man in the foundry, let us rather thank God that the ignorant father was led to do his duty by his son. And such of us as have boys of our own, let us hasten to do likewise; for, rest assured, it is only through determined effort in the right direction, by the fathers of to-day, that future moulders will be superior to those of the past.

But I am persuaded that we have entered upon a new era: the schools are slowly but surely accomplishing their great work; and as education increases, intemperance with its train of evils recedes from view. The sot in our foundries seeks to hide his face rather than to flaunt his shortcomings.

I can with great pleasure now see the leavening influence of intelligence: these young men are the stones, as it were, which mark the march of intellect among us; and before long I hope to see moulders take the place which legitimately belongs to them—the very foremost rank in the trades.

I am anxiously looking for the time when it shall not be necessary to call in the aid of an engineer to arrange for the production of castings of more than ordinary magnitude, and when, by reason of such a course as is

marked out above, such does occur, then will the moulder be able to command such remuneration for his labor as will secure for him the title which by rights belongs to him—the prince of mechanics.

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### TO APPRENTICES.

THE whole of our trade is not learned exclusively in the foundry, and fortunate indeed is the apprentice of to-day in having for his guidance so many avenues of information other than the daily routine of the shop in which he is serving his time. Innumerable opportunities present themselves to-day for the young man's advancement in his trade, which did not exist when some of us were boys. Such being the case, it is surely not too much to expect that superior skill should be developed at this day, when compared with times past. The business of writing on the subject of moulding has until lately been monopolized by theorists, whose efforts have in the main proved failures, so far as the object for which they wrote is concerned, entirely misleading the uninitiated, and of no practical service to the workman; for the simple reason that the author has not had the practical training requisite to understand intelligently what he was writing about.

It is not to be expected that a mere observer of our trade, one who collects his data from books with ideas vague as his own, can understand from such an apprenticeship that which a lifetime's experience in the work itself fails very often to accomplish.

True, there were some few engineers of rare ability in their own sphere who, seeing the necessity for useful and instructive manuals for the use of moulders, wrote works far beyond the intelligence of most moulders, yea, absolutely unintelligible to great numbers, owing to the fact

that the moulders were ignorant of the various branches of natural philosophy, and therefore could not understand them.

These books are only to be found in the employer's office, unused, and covered with dust. During the last few years a gradual change has been taking place. We now find many of our most intelligent moulders who are not afraid of publishing their opinions upon subjects relating to the trade they follow.

It used to be said that our best workmen were the least able to impart their own knowledge to others; but I am proud to say that many of our numbers have come to the front in foundry literature,—conclusively refuting the above stigma.

My object in writing this is certainly not to excel as an author: that would be presumption on my part, inasmuch as my time has been spent in the foundry; but I am anxious to have a plain talk with young moulders, and, if possible, help them to understand their trade, as well as their responsibilities, better, in order to qualify themselves for preferment.

There has always been more or less repugnance on the part of parents to apprentice their boys to the trade of moulder, arising in a large measure from the fact that, to all appearance, it was not as clean and respectable as that of pattern-maker or machinist; and moulders themselves have contributed in no small degree towards making it unpopular, lacking, as they have, a right appreciation of their calling; but, thanks to the influence of superior education, not only moulders, but also the rest of the iron trades, are beginning to realize that the trade of moulder is not only respectable, but that, in order to become an expert in the art, demands are made on the intelligence of the man far greater than are required to master other branches of the metal industries.

The moral tone of our foundries has improved to a remarkable extent of late, and amongst our moulders are now to be found some of the brightest and best men of the day—men with whom no parent need be afraid or ashamed to trust their sons.

Reverting to the subject of cleanliness, I am persuaded that if the same care was exercised to keep the foundry clean and in order as there is for the pattern and machine shop, we should hear less complaints on that head; and when we remember that the great Michael Angelo himself had to work amidst the chips and dust from the stone which he so marvellously chiselled before he could accomplish the mighty works of art he has given to the world, we need not be fastidious with regard to such minor matters.

“What age shall I apprentice my son?” is a question we often hear asked by the parent. If he is to be a moulder, let him not be older than fifteen years, as the nature of the profession demands that the apprenticeship shall be a long one; coming young to the work, he all the more readily adapts himself to the nature of his calling, and has ample time to go through the legitimate routine required to make a good mechanic.

Let me here observe that a great mistake is only too frequently made by the parents when their boy commences work, and the boy himself readily falls into the snare,—which is, to imagine that there is no further need of school and study. Avoid this common error, young man; and realize, if you can, that now is the time to apply such knowledge as you already possess, and that you need to be making constant additions to your knowledge, and preparing the mind for the increased demands which will be made on you, as you march, as it were, step by step to the end of your apprenticeship. The fact that such results ensue from a certain course of action is not the whole so-



lution of the problems which daily present themselves in the foundry; therefore let the intelligent young man, who has chosen to be a moulder, continue his education, by pursuing a course of study at home, or better, at one of the schools of technology, in such branches of natural philosophy as are likely to be of use to him whilst he is learning his trade.

By so doing, a real and intelligent knowledge of the business will be acquired as he goes along, enabling him to do that which hundreds of so-called moulders are unable to do, viz., to give a reason for every step he takes in the execution of his work.

Another desideratum is to cultivate the acquaintance of such of his shopmates as are upright and sober; and in all things, both in and out of the shop, let his deportment be such as will command the respect of his superiors; by so doing he will not only gain their good-will and help, but will also be laying a foundation for the future, which will enhance his prospects more than he thinks for.

Of course the young man must not flatter himself that he is going to master all the intricacies of his trade without meeting many difficulties, and perhaps failures; but if after due effort on his own part he should still fail to see his way clear, let him make known his troubles to the foreman, or some of the most skilful and sensible men, who will at once assist him to overcome his task, and take great pleasure in doing it.

Lastly, he must select for his companions only such as will assist him to rise, being ever ready to reciprocate their efforts in his behalf; maintain a strict integrity and determine to manfully do his share in keeping up a high intellectual and moral standard in his profession.

## A FIRST-CLASS MOULDER.

SUCH is the title applied to many of our trade who, if their capabilities were examined by the light of modern research, would be found utterly wanting in the principles and laws which govern the art of moulding.

It is not enough at this day that a man who takes to himself the above title shall be able to produce a creditable casting from the pattern given him to work from. The probabilities are that everything is found in good form for its production, the methods of manipulation having been thought out by some one in advance of him, either foreman or journeyman—not nnfrequently the latter.

Very many of our so-called “first-class moulders” are clever only in their ability to “catch on” or “pick up” the modes of working going on around them. Such men will have their organs of imitation well developed, and in more senses than one will rank only with the parrot—as mere copyists or imitators. Others, again, having excellent memories, can recall experiences, either of themselves or others, and turn such to good account by avoiding past errors or by again adopting means which have worked successfully in the past, and thus escape present disaster.

It is not my aim to depreciate in any sense the work of men whose natural intelligence is their only recommendation, for it must be admitted that such men have been in the past great factors in foundry practice, and it is not wise to dispute their authority before examining into the ways by which they have arrived at their conclusions; for the lack of acquired knowledge creates within them the good quality of sharp wit, and their very naturalness suggests to them a mode of reasoning which, if not strictly logical, will be found in the main to come so near the

truth as to command the respect of those who are more thoroughly initiated.

Pass through any one of our best foundries, and note the several moulders working at their respective jobs. To the casual observer everything appears to move along smoothly, suggestive of a complete mastery over all the complex and intricate problems to be solved in the construction of the several moulds; in fact, it would appear anomalous to call them at all difficult when we observe the apparent ease with which they are accomplished.

But we are much deceived if we imagine that this has always been the experience of the foundry in question. On making inquiry, we discover that present success is only the result of repeated trials in the past, actual failures discovering to the workman the need of greater care, or increased strength, etc., of the various parts of his mould; and it is not going too far to say that in many instances, when disaster has followed disaster, chance has come to their relief and opened up the way of success.

The only men to-day who can claim the title of "first-class moulders" are they who, seeing the end from the beginning, pursue an intelligent course throughout the whole process of forming their moulds, and are able to give a reason for every move they make.

The moulder must possess constructive ability of no mean order, as demands are made upon him in this particular which call not only for sound practical experience, but for a mental development superior and only possible in such men as have determined to merit the title above mentioned, and studiously and zealously work to maintain such title. Not only ought the several branches of the trade—loam, green-sand, dry-sand, and core-making—be all equally mastered by him, but also the ability to produce the molten iron for the finished mould in such mixture and condition as will best serve the requirements of the case.

How can any moulder claim to be "first-class" who cannot judge of the fitness of the cores supplied for his mould, and must in all cases trust to the core-maker, whose knowledge of the matter may be even less than his own, and very naturally so, too, when we consider that, from a misconception of the value and importance of that particular branch of the trade, even green laborers are permitted to produce such cores,—a simple case of the blind leading the blind, with the inevitable result of both falling into the ditch? Nor would there be any justice in the claim for excellence made by any moulder skilled only in one department of his trade, to the exclusion of all the rest.

The basis of excellence consists in the association of all the branches, inclusive of the cupola (last, but not least); and it is not too much to expect in these days, when the opportunities for the acquisition of knowledge are so plentiful, that a first-class moulder shall answer to the standard herein laid down.

The really first-class moulder leaves nothing to chance, and, as before stated, "sees the end from the beginning," every step he takes in the prosecution of his work manifesting a previous study of the science of his business. He *knows* that his sand is suitable, because, along with his own experience and observations, he has studied the subject thoroughly, and can tell beforehand what mixture he needs to bring the silica, alumina, etc., into correct proportions for the work in hand.

The flasks and other rigging he makes will be reliable, because he will have made the necessary calculations as to the weight to be sustained and pressures to be resisted, and proportions his arrangements accordingly. The oft-repeated query of the foundry, "I wonder if this is strong enough?" never enters his mind: he *knows* it is.

Should it be required that a mould must be secured by

weights, the first-class moulder never wonders how much weight he ought to place thereon. He has made a careful study of hydrostatics and kindred subjects, and applies the knowledge gained thereby to his every-day practice. By this means all the apparent mystery in moulding is made to vanish in a manner truly astonishing to his shop-mates who are so unfortunate as to have joined the "pooh-bah" association.

To sum up, ignorance is at the bottom of all this so-called mystery in the foundry. I shall be amply repaid for this writing if I awaken in moulders a greater desire for knowledge than has manifested itself hitherto. It is foolish to say, as some do: "Oh, my education was very limited," or, "I never went to school." To the former I say: Then finish your education now; and to the latter, Begin at once. Surely there is more pleasure in growing wiser, be it ever so slowly, than there is in remaining ignorant, only to be laughed at by the more ambitious ones around us.

To the young men in our foundries I would say, Keep up your education by constant application to study. You need all the knowledge you can get to thoroughly understand your trade. Schools of instruction are becoming numerous all over the land, and must not be despised as means for culture in the trades. In these institutions intelligent workmen may receive such instructions as will perfect their practical education and make them in every respect worthy the name of "first-class moulder." Lacking the opportunities of such schools, the moulder must make a school for himself. It is important to study. Where one studies is of minor importance. In these times, when opportunities for learning are more than plenty, there is no excuse for ignorance.

## EDUCATED MOULDERS.

A MORE SCIENTIFIC EDUCATION NEEDED—GOOD WORKMEN MUST UNDERSTAND THEIR WORK IN ALL ITS DETAILS.

MOULDERS need instruction in some of the parts which go to make up a purely “scientific” education, whether they are supposed to receive such an education or not.

The science of figures, of geometry, of chemistry, and all knowledge which relates to these subjects, ought at least to be measurably known to every moulder who aspires to be recognized as an authority on foundry matters.

Because a man has reached the age of twenty-five, or even forty-five, before he discovers this fact need not deter him from at once proceeding to rectify the mistake he has made; and, depend upon it, all that is required, even at the latter age, is a firm determination to make the future, in some measure at least, correct the errors of the past.

Some one has said, “A good mathematician would make a good man at anything else he might essay to do.” This is true, as it is impossible for any one to excel in the science who cannot concentrate his whole mind diligently on the one subject; and any man who possesses this power of concentration need not hesitate about qualifying himself in the branches of science before mentioned.

Moulders need to bestir themselves in this matter; for those who cannot read “drawings,” for instance, however capable they may be in other respects, are being gradually relegated to the ranks of incapables.

As well might we expect to see the draughtsman instructing the pattern-maker from the drawing which he, the pattern-maker, ought to be able to read as that the pattern-maker should have to be sent for to instruct the

moulder in laying out his work—a truly sad sight in any foundry, when the nature of the case is fairly understood. The only man who can claim to be a thorough moulder, in this particular, is he who can “read” the drawing from which he is expected to work sufficiently well to enable him to accomplish his jobs without the aid of any one.

There need be no hesitation about undertaking these studies on account of their seeming irksomeness, for, rest assured, once they are begun each exercise will furnish the desire for further effort. Nor is it to be thought that because a man works hard ten hours a day that he is unfit for any further endeavor. I would say to such, that an hour or two, each evening, spent in the pursuit of knowledge would tend not only to the development of the mind, but of the body also.

By such a course the mind, being fully occupied with these higher pursuits, disdains the grosser elements which have hitherto predominated there, and consequently the whole man is benefited mentally, physically, and morally.

An almost universal complaint amongst moulders is “that the trade is a monotonous one.” To a great many this is strictly true, for the simple reason that they allow themselves to lapse into automatons, doing the same things every day with the same precision as the machinery around them, and with about the same amount of thought.

They never share in the satisfaction which comes with the successful result of intelligent research and observation, nor is it theirs to enjoy the practical demonstrations of the wonders of philosophy which are constantly taking place around them, giving a zest to toil which makes it attractive rather than monotonous.

Moulders, arouse yourselves! Accept the means offered by the many institutions all around you. Teachers abound who, at reasonable salaries, would take charge of such mutual-improvement associations as might be formed in

direct connection with the trade-unions, thus making them benefit associations in more senses than one.

In almost every city of note is now to be found a school of technology, to which all thoughtful moulders in the vicinity should attach themselves at once.

Lastly, educational literature is now so very cheap that there is absolutely no excuse for ignorance. All may, if they will, become intelligent in the things pertaining to their trade, and thus make it a pleasure instead of a toil.

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### APPRENTICESHIP BY INDENTURE.

IN discussing this subject I shall confine myself strictly to the trade of moulder, it being the trade with which I am most familiar.

Writers in large numbers have come forward of late to explain the difficulties which beset the several trades and professions to which they belong, some arguing the justice and propriety of adopting the old and time-honored system of apprenticeship, whilst others, equally anxious for their individual welfare, have supported the doctrines of Dr. Adam Smith, who claimed that a long apprenticeship was unnecessary, even for the nicest mechanical arts; the fallacy of which doctrine we shall endeavor to show, at least so far as it relates to the trade of moulder.

To such as are ignorant of the moulder's art, the whole business seems an unfathomable mystery, and even to such as have a superficial knowledge of the trade it is full of interest, ever growing, as one after another of the various processes are revealed, resulting in the finished work which they unfeignedly pronounce "admirable."

Granting the above, it would appear that more than



an ordinary course of preparation is needed to make a thorough moulder; and when I say a thorough moulder, I mean all which the words imply,—not in any sense such a one as is generally understood.

Usually it is said, “such a one is a good pipe-moulder,” another is a “good plate-moulder,” a “good column-moulder,” or a “good propeller-wheel moulder,” etc.; but it must be borne in mind that very many of these are good only at such special work, and not in any sense master of that one job, for the very simple reason that all their manipulations are not based upon a thorough knowledge of the trade, but are mere acts of memory on their part, doing only that which they have seen done before by other men, thus enacting the part of the parrot—imitators. Such men are easily discovered, even when engaged on their specialties, for when anything occurs out of the ordinary line of their daily drudgery, something which calls for a different line of thought and action, they are at once confounded, and endeavor to escape their dilemma by pronouncing the whole thing a “mystery,” and “chancing” it—with the inevitable result of a bad casting.

Now this state of things is not confined to one foundry: all have more or less of this incompetency to contend with; therefore all ought to be equally interested in finding a remedy for it.

If we inquire into the status of the men above mentioned, we shall find that the majority of them have no claim to be called moulders, other than the fact that they had helped a moulder until they were twenty or twenty-five years old, after which the foreman or employer was prevailed upon to “give them a show;” the show is given, with the result as above stated.

Hundreds of others assume the name of moulder, and assert their ability to perform any kind of work creditably and with dispatch; they back their assertions by informing

you that their trade was learned at a first-class establishment; upon these statements they are hired, and it seems incredible that such frauds as they prove themselves to be could have graduated from the firms they refer you to.

The reason is plain, however: upon inquiry you discover that their boyhood was spent in one wild riot, the business they had engaged to learn being the last thing thought of by them; and just here let me say that it is a very rare occurrence to find our boys in full accord with their employers after the novelty of initiation into the trade has passed: a spirit of distrust, which seems mutual, appears to pervade both sides. The boy, more or less under the evil influence of the ruder spirits around him, assumes an air of false independence, and asserts that he is not being rewarded according to his deserts, threatens to leave, makes things generally uncomfortable for all concerned, and finally quits, to the infinite relief of everybody, without having acquired even the rudiments of the trade his parents were anxious for him to learn. On the other hand, it not unfrequently happens that a boy engages with some unprincipled employer, whose only object is to get all he can out of him as long as the boy is willing to suffer the injustice; but just as soon as he rebels, his place is wanted for some other victim: this is a crying injustice, and calls for prompt redress.

When all these and kindred evils are considered, is it any wonder that we have such an army of incompetents, who insist upon being recognized as moulders, and does it not behoove us as artisans to look for a remedy? I go further, and assert that this question of inferiority as moulders is becoming a national one, for are we not called upon to witness the superior skill of the strangers who come to make their homes amongst us?

Well, you say, what remedy do you suggest? I unhesitatingly answer, let us go back to the old method of apprenticeships by indenture, which has proved to be the

only reliable safeguard against difficulties such as we have been describing.

Justice and honor demand that we approach this subject unbiased, and with fairness to all concerned,—the boy, the parent, the employer, and last, but not least, the national credit.

Some one says, Are there no good American moulders? There are some, but they are those whose boyhood days were watched over with deep solicitude by discerning parents or guardians, backed by a desire on the part of the employers to do their full duty by the charge placed in their hands; thus in reality fulfilling every obligation which a sensible indenture would bind them to.

Others again amongst us, whose claims for competency are well established, may not have had all the advantages of early training, but possessed of good natural ability, coupled with an indomitable will, they have determined to become thorough masters of the trade, and hesitating at no sacrifice which the urgency of the case demanded, they have pushed themselves to the front, and deservedly so; but these are a very small minority, and we feel assured that such men will heartily indorse any action which will insure an easier and surer way of lifting their fellow-men to the front ranks in their profession.

It is urged by some of the opponents to the system of apprenticeship, that the institution interfered with the property which every man has or ought to have in his own labor, and also that the object is to maintain a high rate of wages by stinting the number of persons who are engaged in the occupation. Dr. Adam Smith, above referred to, and some of his school, claimed that it not only interfered with the liberty of the workman, but also with that of such as may choose to employ him, who were the best qualified to judge of his ability. They further contend that such laws tended to restrain competition to a much smaller num-

ber than would otherwise enter a trade. They also limit the time necessary to learn such trades as watch and clock making to a few weeks, or even days.

Whilst some of these arguments may seem feasible, there is to my mind a good deal of error running through the whole, specially the latter, in regard to length of time necessary to learn a trade, which is simply ridiculous.

“Apprenticeship, in law, is a contract whereby one person, called the master, binds himself to teach and another, called the apprentice, undertakes to learn some trade or profession, and to serve his master some length of time.”

The object of the above is to secure for the apprentice such a degree of proficiency in his trade as will enable him to earn his living creditably, the only return for which is a certain stipulated time of servitude to the person engaged with.

Let us look at some of the advantages this method offers to the boy. In the first place, allowing that the age of the boy is fourteen years, there is comparatively no difficulty in getting him into full sympathy with the agreement, whose conditions become part of his belief, and consequently part of himself; any irksomeness which might present itself to him is immediately dispelled when he remembers that his skill as a moulder is increasing as the years go by, thus creating an ambition to be esteemed a man and an artist when he shall have attained his majority.

The advantages of a legal apprenticeship can only be fully appreciated by such as have passed through that degree of probation, especially when all the conditions have been met, mutually, by both parties to the contract.

The method engenders a feeling of kind regard for each other, as it is always to the employer's interest to be kind to his apprentices, and take pride in watching their steady progress.

From experience, as well as from information carefully gathered, I am persuaded that a boy duly apprenticed receives a greater share of the journeyman's sympathy and help than do those who are casually engaged to serve a full time or otherwise, as either or both shall determine.

No moulder of good sound judgment and practical ability can pass through our foundries without being struck by the slipshod manner and methods the majority of our moulders exhibit in the use of their tools, a large number of which tools are practically useless to most of them, for the reason that their apprenticeship was neither long enough nor as thorough as it ought to have been, to acquire a nice artistic use of them.

Who ever thinks of making a thorough musician of his boy, after allowing most of his young days to be spent at some hard calling, which demanded more than ordinary use of the hands? After such training it would be impossible for the youth to adapt his fingers to the nice manipulation required to give due effect to string or key of the instrument chosen for him. And just so is it with regard to a moulder: a boy entering the trade in his early youth, under the favorable auspices mentioned above, attains to such a degree of proficiency in the use of his tools that nothing can deter him from turning out his work, stamped on every part with the mark of a true artist.

The question may be asked, "Who will be the gainer by the adoption of a general system of lawful apprenticeship—the artisan or the employer?" I answer, both; and further, I claim that it would be productive of a better class of citizens, and therefore a national benefit.

It seems to me that the moulders' unions could by a supreme effort become the pioneers in a movement which would bring about the above-mentioned reform, and I feel assured that no nobler object could possibly command their serious attention at the present moment.

I am aware that it will be urged by some that it will tend to make the trade more exclusive; but that, I claim, is their right equally with the professions, who for very good reasons claim protection on account of the forced apprenticeship to which they were subjected before they could obtain their diplomas.

But does not the public gain by the system, inasmuch as they are protected against fraud and deception? And just so would employers be protected against incapable mechanics. This latter ought to commend itself to the earnest consideration of all employers, causing them to co-operate with the trades unions, with the view of establishing a sound system of apprenticeship.

This done, I have no hesitation in saying that the next generation of moulders would verify all I have said on this subject, and prove themselves equal, if not superior, to any in the world.

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### MOULDERS' TOOLS—THEIR USE AND THEIR ABUSE.

SOME one has said that "neither wise men nor fools could work without tools," and again, that "the poor workman is always finding fault with his tools;" but if his tools are the only things he assails, we may leave him to his quarrelling, and endeavor to do better ourselves by not only having the proper tools, but by having a full knowledge of their right use.

By some it is thought that a moulder requires very few tools and that "few" of a very simple kind, and some moulders themselves boast of their ability to accomplish their work as well with a coat-pocket full of tools as others whose tool-chest is packed full of them; but if

these gentry are carefully watched it will be discovered that they are constantly borrowing from their neighbors to make up for their own deficiency.

Another thing we may notice here is, that no small number of our so-called journeymen moulders really need but very few tools, never having learned the proper use of them all, in consequence of which their jobs are turned out by hand, so to speak: in other words, made as well as their hands and a big square trowel can make them—a disgrace to the man as well as to the foundry that employs him.

It is my purpose herein to explain the simplest tools used in the trade, as I see almost every day a misuse made of them.

The shovel, for instance, to some men's minds is a thing of very small importance; no attention is paid to keeping it clean and well trimmed: they seem to forget that such neglect makes it much harder to dig with, or to clean off a joint, and of course the lives of both man and shovel are materially shortened thereby.

Brushes, riddles, sieves, and bellows are equally ill-cared for, with a similar result. I advocate the method of supplying each moulder with a full set of the articles above mentioned, holding him responsible for their safe keeping, and to be returned when he leaves.

It is customary for firms to supply these articles; but, excepting the shovels, they allow only a limited number of the others for general use: this is a mistake. I have tried both plans, and always found the former to work most profitably.

Clamps and wedges come under the head of tools supplied by the firm, and, simple though they seem, it is important that they be made correctly, otherwise disaster very frequently ensues.

Clamps should always be made with the view of being

strong enough to resist the pressure exerted by the mould they are intended to secure. Very often we find them made with the corners rounded, as shown at Fig. 1; this is wrong, inasmuch as it reduces the part which is called upon to bear the most strain to the weakest part of the clamp.

Clamps should always be made after the manner shown at Fig. 2, especially such as are made of cast-iron.

We come now to wedges, which ought, if possible, to

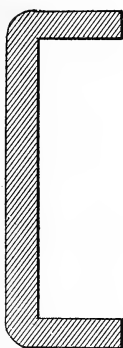


Fig. 1.

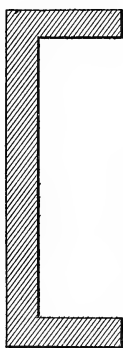


Fig. 2.



Fig. 3.



Fig. 4.

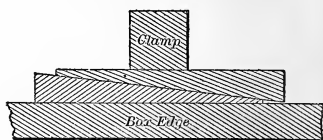


Fig. 5.

be made of wrought-iron, and fashioned as shown at Fig. 3, not as we frequently find them, as seen at Fig. 4.

Those shown at Fig. 3 may be used two together for work requiring great security; Fig. 5 illustrates the method of using them; the others are simply valueless for critical jobs, and ought to be discarded.

A screw-driver and wrench, if not supplied by the firm, should be purchased for private use by every moulder, the former being always at hand to loosen any part of a pattern that will facilitate the moulding of the job; whilst the latter will save hours of time and much dis-



appointment in hunting up the one belonging to the shop, which, strange to say, is always lost when wanted.

To a careful moulder a pair of calipers is indispensable. How ridiculous the man appears when, upon trying off his cope, he finds more or less of his upper bearings crushed off on account of the cores being too large; or, opposite to this, when his casting is examined the core is found out of the centre, for the simple reason that his core was too small: either of which faults could have been avoided by a right use of the tool above mentioned!

Parallel straight-edges, level, compasses, trammels, and square are usually supposed to be required by the loam-moulder only. I claim that every moulder should possess these tools, and what is more, he ought to make himself acquainted with their uses; for he knows not when he may be called upon to demonstrate whether he knows his business fully or not.

How simple one of our best green-sand moulders is made to appear when, if called upon to make plates or rings for the loam-moulder, he stands aside whilst the latter marks out the lines for his guidance! This ought to inspire every moulder to learn all of his trade, and save him the disgrace which such a thing subjects him to.

For the guidance of such as are ignorant of, and desire to learn, the use of the above-mentioned tools, I will here describe the whole process of levelling a bed, and drawing thereon a simple job.

Fig. 6 explains the process of laying down the straight-edges preparatory to making the sand-bed thereon.

The straight-edge *A* is first set level in the floor, resting on each end only; straight-edge *B* is then set similarly, at the required width; the parallel straight-edge *C* is set across the ends of both, as shown, and the end of *B* raised or lowered until the level shows it to be level with *A*; the level is then placed lengthwise on *B*, and the opposite end

regulated until *B* is level also. The straight-edges are now secured, and the sand-bed prepared in such a manner as will best suit the job as to depth and degree of hardness.

We will suppose a plate is to be made square at the outer, and round at the inner edges, having six equal divisions drawn on the inner circle, one lug in the middle on each of the four sides, and four round holes in some

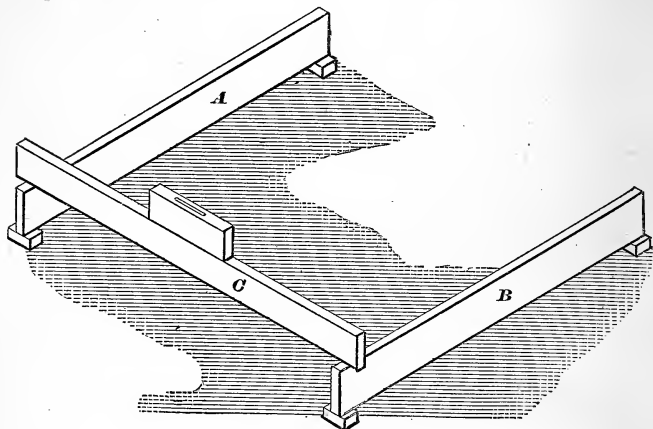


Fig. 6.

certain position cast in the body of the plate, as seen at Fig. 7.

After setting in a centre-peg *A*, with small hole for the point of the trammel to work in, lay straight-edge *B* parallel with the bed, and fair across the centre at *A* draw a line across, cutting the centre hole; then set the square *C* against the straight-edge, with the corner true to the centre hole; keep the square exact in this position whilst you move the straight-edge and place it against the other side of the square, after which the square is removed and line *D* is drawn. You now have two centre-lines at right

angles to each other, from which lines you must measure for width and length of plate outside.

All that is now required for describing the four holes in the body of the plate is to ascertain their distance from the centre-lines, marking them off each way as shown at *EE*; the intersecting point of these lines will be the centre of the holes required.

Because the sides are all equidistant from the centre,

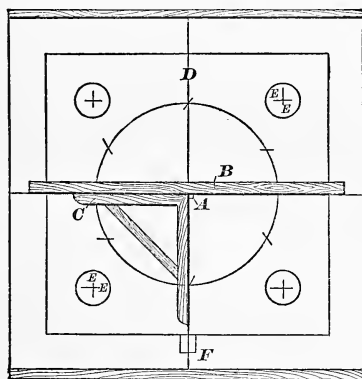


Fig. 7.

the centre-lines themselves give the position of the lugs as seen at *F*.

All that now remains to be done is to set the trammels to the required radius and draw the circle, the six divisions of which are obtained by marking off the length of the radius used to draw the circle. Any number of divisions of the circle in this proportion can be got by subdivision of the six, as twelve, twenty-four, forty-eight, etc.

It will be observed that the circle is divided in four by the centre-lines: subdivisions of these will give eight, sixteen, thirty-two, etc. To such as are scholars this short lesson will be uninteresting; but to others who are

ignorant of geometry I say, Do not rest at this simple illustration; get books on the subject, and study hard: it will repay you.

A small water-pot with neat swab is a useful adjunct to a moulder's outfit, providing it is used with discretion. A careful workman has one for his own private use, to stiffen an edge with where it is absolutely necessary; but should it be required to use more water than is good for the safety of the mould, he will see to it that the extra moisture is dried out before he casts.

Not so the careless or the incompetent workman: he uses water to save labor in finishing, and should his casting be measurably free from blisters and scabs, which is very rarely the case, it is certain that holes will be found in the upper surfaces, caused by the extraordinary amount of steam which is generated in such a damp mould, and which steam no ordinary amount of venting will carry away.

This brings us to the subject of vent-wires and how to make them. Large vent-wires should always have the point made as shown at Fig. 8; this enlarged point enters the sand freely, making a hole larger than the body of the wire, which follows after without friction. Smaller wires only need to be filed square at the end, which should be jumped up a little by a few blows endwise; Fig. 9 gives an idea of what I mean.

Gaggers may be considered moulders' tools, as they play a very important part in his work, very many castings being lost either from having too many or too few, or from not having the right kind. I have shown three kinds of gaggers at Figs. 10, 11, and 12. Where the amount of sand to be lifted is not too deep below the bars of the flask, Fig. 10 will serve the purpose. The principle involved is to secure, by ramming between the bars, the gaggers placed therein, so firmly that the weight of the

hanging sand will not be sufficient to pull them out. Usually, when such is the case, recourse is had to chucking; but very much of the wood used for this purpose may be saved by using the gaggers shown at Figs. 11 and 12. These hang on the bars of the flask, thus making failure to lift impossible.

The subject of flasks is a very important one. A chapter has therefore been devoted to its discussion exclusively, to which I refer the reader, as I have treated that subject



Fig. 8.



Fig. 9.

*American Machinist*

Fig. 10.

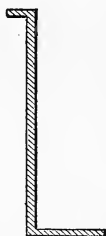


Fig. 11.

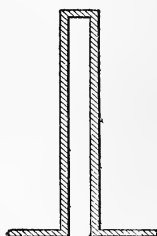


Fig. 12.

more fully there than I could be expected to in this writing.

We will now consider the subject of ramming or packing the sand against the pattern. This is accomplished by tools called rammers, which rammers, if used properly, will not only prevent the casting from swelling out of shape, but will also save considerable finishing by the moulder. The wooden rammer shown at Fig. 13 is used by bench-moulders to ram small flasks and snaps with: this kind is preferred by most of them, because they can use one in each hand, if they choose, thereby materially lessening the length of time needed to ram up their flasks; but for general jobbing work, on the floor and in larger

flasks, it is necessary to have rammers suited to the height of the moulder who uses them, as he must invariably stand

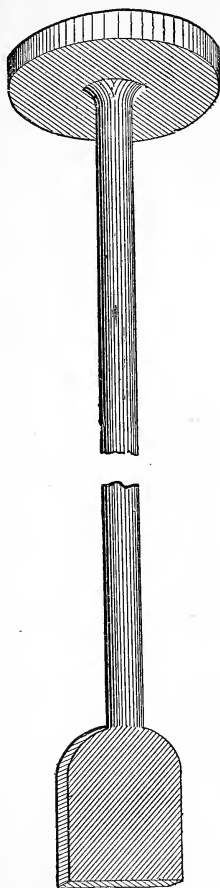


Fig. 13.

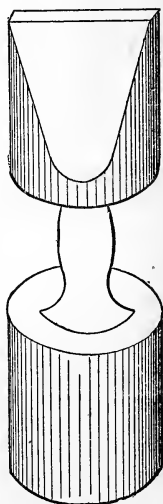


Fig. 14.

to his work. Fig. 14 shows the kind of rammer most suitable for floor work: it may be either double or single

ended, the shank may be of piping with ends cast or forged on, or the whole rammer may be forged solid. As stated, ramming is a very important operation, and the art should be learned thoroughly, as no amount of finishing will rectify faulty ramming. How often we see castings swelled in parts all along the side surfaces, or, if not swelled, blotches and scabs all over: both evils caused by inattention or inability, as the former results from ram-

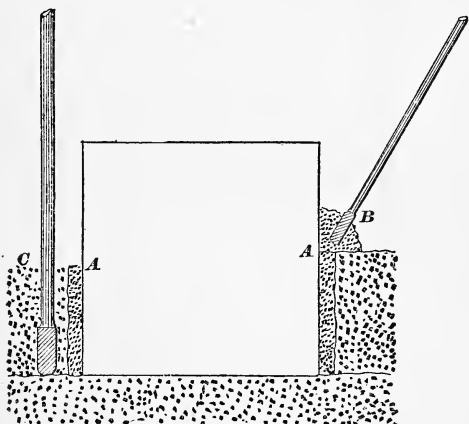


Fig. 15.

ming too far away from the pattern, and the latter from ramming too close,—in all probability frequently striking the pattern with the rammer!

Again, how many comparatively good castings are marred by the ugly seam running along just where the one course of ramming joins the other!

By the use of Figs. 15 and 16 I shall endeavor to give a remedy for the evils spoken of. The figures show a round and square pipe or column bedded down in the floor or flask; it is at the joints *A, A* where the seams are formed, by continuing the ramming without first making the con-

nection between the two layers of sand good and solid. This is remedied by laying down the facing-sand along the pattern, and carefully packing the joint with a smaller rammer made for the purpose, as seen at *B, B*, after which the facing can be pressed against the pattern, and backed with old sand; the ramming can then be continued as shown at *C, C*, taking care to reach the bottom at each stroke, and never allowing the rammer to come closer than two inches from the pattern.

We come now to the more artistic class of tools, such as are usually called finishing-tools, a full set of which

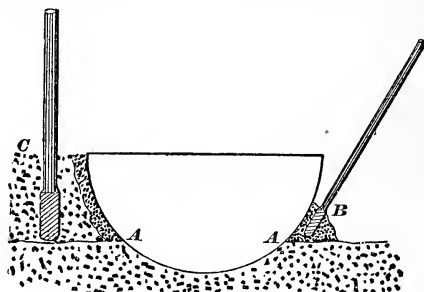


Fig. 16.

it ought to be the pride of every moulder, man or boy, to possess. The square trowel, Fig. 17, first claims our attention, because it is the most used. Of these there should be four, from four inches to seven inches long, of suitable widths according to length; they should be stiff and unyielding, with an even surface on the face. This enables the moulder to retain a perfectly even surface on the face of whatever part of the mould he smooths with them. This is worth consideration; for, painful as it is to relate, a careful inspection of some of our best work will reveal some very ugly marks, caused by finishing such surfaces with old round-faced trowels.

As these trowels wear down and become pliable they



are invaluable on curved surfaces, especially for loam and dry-sand work. Fig. 18 shows how such tools may be

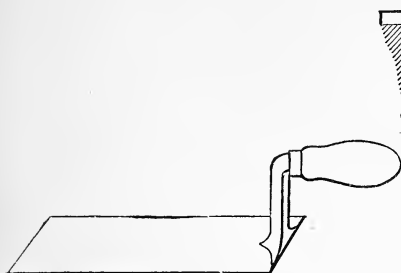


Fig. 17.

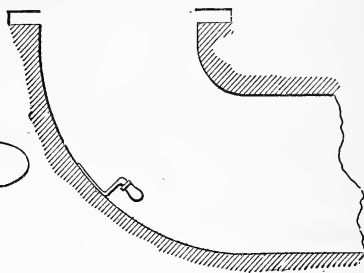


Fig. 18.

used, the trowel being bent to suit the contour of an elbow-pipe.

One heart-trowel of good size, Fig. 19, will be found useful, as the point enables you to reach places impossible of access by the square trowel.

Fig. 20 shows a combination of heart and square,—a very

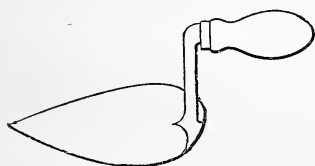


Fig. 19.



Fig. 20.

useful tool in good hands, and one which may be made to do good service.

I have many reasons for saying “careful” in reference to the use of moulders’ tools of all descriptions; for I am sorry to say that very many of our moulders, when they obtain a very handy tool, take infinite delight in smoothing away on the surface which it fits, either heedless or

ignorant of the fact that by so doing they work the moisture, mixed with more or less clay, to the front. By and by this clayey surface clings to the tool and comes away in patches; the *ignorant* moulder then proceeds to fill



Fig. 21.

up the bad spots with his trowel, smoothing it on the whole surface indiscriminately, good and bad spots alike; the pressure he exerts to press in this sand loosens the



Fig. 22.

already overworked surface, which yields to the first touch of the molten iron, and an unsightly scar is the consequence. But irrespective of the above, it must be

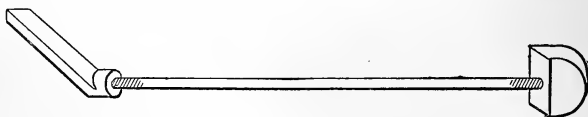


Fig. 23.

remembered that the hard clayey surface caused by over-smoothing with the tools expands as soon as the molten iron reaches it, and this expansion not being equal all over

the surface, but by degrees as the mould fills up, the skin of the mould buckles, causing a very unsightly as well as undesirable surface on the casting.



Fig. 24.

Lifters shown at Fig. 21 ought to range from a quarter of an inch in width about six inches long, and advance in size by eighths up to two inches wide, lengths to suit. A

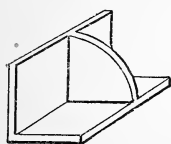


Fig. 25.

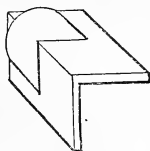


Fig. 26.

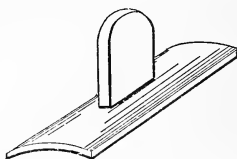


Fig. 27.

very necessary adjunct to the lifter is the web-smoothers, shown at Figs. 22 and 23: these should be made to match the lifters as nearly as possible; they can be either cast or

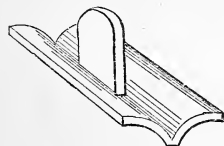


Fig. 28.

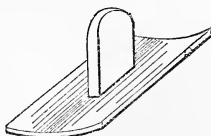


Fig. 29.

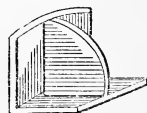


Fig. 30.

forged in the form shown at Fig. 22, or threaded shanks of different lengths and stiffness can be procured, on which loose ends may be screwed (Fig. 23). The latter method is

very advantageous, as almost every variety of tool may be cast at a slight cost; another advantage is that they are much less bulky than those which are forged or cast in one piece. These tools serve a good purpose, as they enable the moulder to finish the bottom of a web with dispatch, and with greater nicety than it would be possible to do with the lifter alone.

Bead and flange tools, such as shown at Fig. 24, may be cast in one piece, or the ends may be loose, as just described.

Figs. 25 and 26 show smoothers with two faces at right

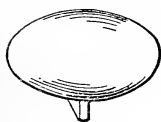


Fig. 31.



Fig. 32.



Fig. 33.

angles to each other; one is concave and the other convex. These tools should only be used to give the final touch at the corners, after the mould has been made perfectly true.

Figs. 27 and 28 represent a set of flute tools, the one at 28 reaching the outer edge and a part of the curve on each side, the one at 27 finishing the curve.

Again, let me say that it is very tempting, especially to youth, to overwork the mould with these tools, they run along so easily, also avoid all smoothing until the faces have been well secured, and then do no more of it than is absolutely necessary.

Smoothers, such as shown at Fig. 29, are made of different sizes to fit all diameters of pipes, columns, etc. The

one shown at Fig. 30 is similar to Fig. 25, excepting that one of its sides is circular, and serves to smooth a corner, one side of which is flat and the other round. This class of tool may be made to any angle or shape required.

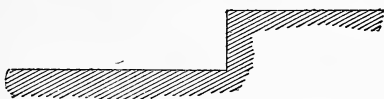


Fig. 34.

Fig. 31 shows the form of tool required to fit the bends of elbow-pipes, etc., and needs to be of several sizes to suit the diameter of pipe: for this purpose they are best egg-shaped, as seen; for globes, the outer edge must be made to a true circle.

Figs. 32 and 33 are simply modifications of the one seen at Fig. 22, any number of which may be made, in cast-iron or brass, to fit the job.



Fig. 35.

In conclusion, let me draw the attention of the moulder to another class of tools, the cheapest of all, but, if rightly used, the most productive of real artistic work. I mean strips of wood to be used for re-forming the broken surfaces, too frequently seen in the mould when a bad pattern is drawn from the sand; or when a bad lift occurs in the cope.

A simple example will best serve the purpose of illustration. Suppose Fig. 34 to represent the surface required,

but the edge at *A* is broken, as seen at Fig. 35; never make the attempt to repair such a job by patching with the tool after the manner shown at Fig. 36, but have a long

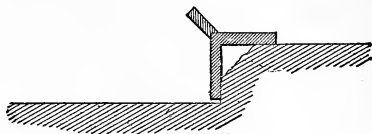


Fig. 36.

strip made the correct depth of the return, set it against the edge, as seen at Fig. 37, and make the corner good all along, after which the requisite tools may be used to finish with, and a true mould will result.

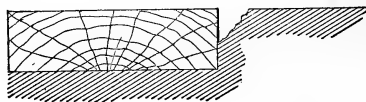


Fig. 37.

The above-described method of finishing put into general practice will not only secure the best work, thereby gaining distinction for the moulder, but will also facilitate production to a very appreciable extent, thus making it better for all parties concerned.

# FOUNDRY FLASKS OR BOXES.

FLASKS or moulding-boxes in which the patterns are rammed are made with the view of confining the amount of sand to be used to its smallest limit, consistent with safety, and should be made of such dimensions as will allow of the rammer being used at the distance of from 2 inches to 3 inches from the pattern. If made of wood, there must be a sufficient body of sand between the casting and flask to prevent damage from burning. On this account iron flasks (as a rule) can be made much smaller, thereby saving time and labor in filling in.

Fig. 38 shows a 14-inch iron flask for small work, and

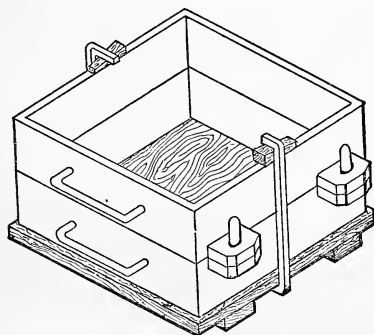


Fig. 38.

where a large quantity of machinery small work is made, such flasks are much superior to wooden ones. Having no bars top or bottom, they are readily rammed and closed, two clamps being sufficient to bind them together for casting.

But when there comes a job-requiring large numbers of extra-light castings, the sand can be rammed in a snap flask, in the same manner as in the iron one and when

the mould is closed the flask can be loosened off and the sand cope held down by a flat weight heavy enough to resist the pressure when cast, a hole being cast in the weight to expose the runner or gate. Such a flask is shown at Fig. 39. The hinges and latches are seen at opposite corners, the other corners being bolted or screwed fast. The great advantage in this kind of flask (where it can be used with safety) is the number of iron or wood

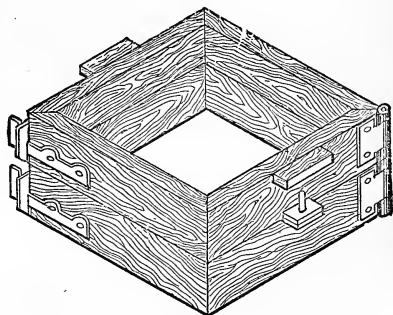


Fig. 39.

flasks it saves, as well as the rapidity with which it can be worked.

Fig. 40 is a perspective view of a 24-inch flask. As will be seen, this method does away with the necessity for either clamps, boards, or plates, the bottom or drag part, as seen at Fig. 41, having flat bars cast on. The intermediate parts or cheeks can be made of any depth required. The pin-holes being bored to templet insures a fit, no matter which parts are used. The flask shown has cheek 12 inches deep; others can be made of different depths, enabling the moulder to rig up a part flask to suit his job in very short order, nothing being required but the pins and keys, which must be kept in order by some responsible man, who will see that they are taken out and stored when not in use. Internal flanges may be cast on the bottom edge



of the cheeks to suit the kind of work they may be used for. For general jobbing purposes this method of making

Fig. 40.

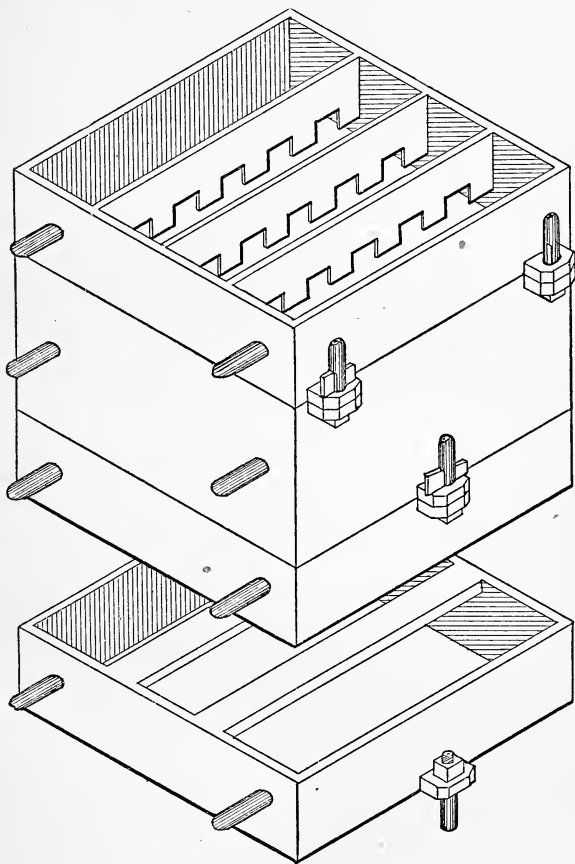


Fig. 41.

flasks is good, for, though a little expensive at first, they pay well in the end.

## LARGER FLASKS, COPES, ETC.

At Fig. 42 a 4-foot cheek part 12 inches deep is shown, with internal flange to carry grates, which may be made to fit any form of pattern, as shown at *A* and *B*, the grate in the former fitting a circle, the latter being square, such as would be required for tanks, etc. The lugs are strong and the bolt-holes are cast in; but the holes for pins must be drilled to templet, so that any cheek may be used for cope or drag. The half-inch strips cast on the edges give strength sufficient for this sized flask, and are more easily made than flanges. The lugs must be rammed in a core and bedded against the pattern, and care must be taken to have the holes for bolts made right and left. The internal flange adds strength to the flask, and enables the moulder to rig up for any kind of job at no greater expense than a few grates.

At Fig. 43 I have shown the way to make the cope and drag; the notches in the bars will be appreciated by jobbing moulders particularly. *A* shows bar for cope, and *B* for drag. Where it is practicable, wrought-iron swivels can be cast in, as shown at *C*, Fig. 42; but if swivels must be cast-iron, let them be strong, as shown at *C*, Fig. 43.

It would be preposterous for me to lay down rules for lifting and handling flasks which would be applicable to all shops; but I show at Fig. 43 two other methods for lifting purposes, besides the swivels. The one at *D* is a cast handle made in a core, and set against the pattern when the flask is made; of course wrought-iron may be substituted, which is better. At *E* is shown a plain lug, into which, when needed, the ring-bolt *F* can be made fast. The latter is very simple, and can be made of universal application. Fig. 44 gives plan of a plain cope for floor uses (without flange top or bottom) 8 feet square;

it has 15-inch square hole in centre. This flask must be 9 inches deep and 1 inch thick on the outside and  $\frac{7}{8}$  inch in the

Fig. 42.

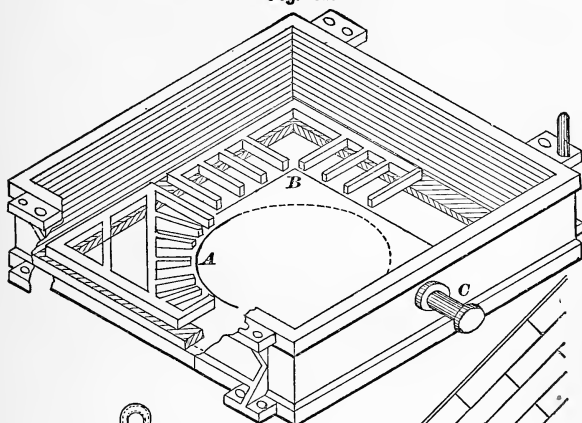


Fig. 44.

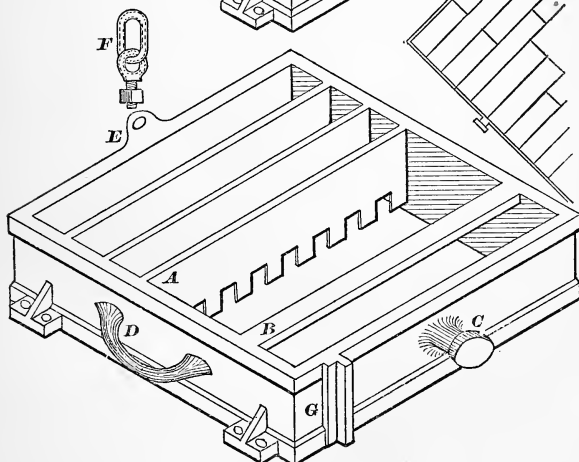


Fig. 43.

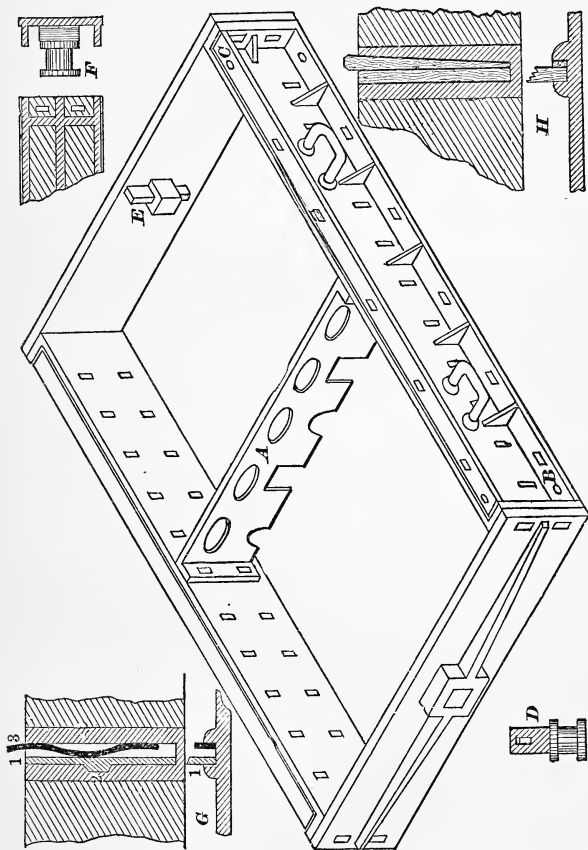
bars. Staking pieces can be cast on, as shown at *G*, Fig. 43. Let the cross on tie-bars be placed as seen. The reason for sides and bars being so near alike in thickness is that

the expansion and contraction whilst the box is in use may be kept as near alike as possible all over. The arrangement of cross-bars is intended to counteract in some measure the inequalities of the thrust, giving, as they do, elasticity to the structure. A box of this kind, cast with good strong iron, will outlast any other kind that is made for floor purposes. When the sides are made heavy, with flanges, etc., cast to their bars, you may look out for a broken box before it has been in use very long.

#### FLASKS MADE UP OF LOOSE SIDES, ENDS, AND BARS.

Fig. 45 is a view of sides, ends, and bar for a flask 5 feet wide by 8 feet long and 12 inches deep. As in this case all the parts may be cast in open sand, a very large flask may be strongly made at a light expense comparatively. It will, of course, be readily seen that (if boxes must be made to fit the job and save labor in moulding) unless some other plan be adopted than to make them all in one piece, the foundry would soon be full of unwieldy flasks, costing considerable time and money to make. It is to overcome this difficulty that the method shown at Fig. 45 is brought into use. It will be seen at *A* that the bars can be cast to fit any form of pattern; the sides can be made to bolt together as cope and nowel, holes for pins being drilled as shown at *B* and *C*; the flanges can be bracketed to any required degree of strength. Let the flanges stand in from the edge of side  $\frac{1}{4}$  inch so as to leave a space of  $\frac{1}{2}$  inch when they come together, into which mud can be pressed to prevent running out. The end shown is for a wrought swivel *D*, which is secured by a key as seen at *E*. Should the box be very wide, and require to be turned over on the swivels, the ends can be still further stiffened, as shown at *F*. At *G* I have shown another method, which saves bolting of all the bars; this method

necessitates the casting of pockets on the sides to receive the end of a plain bar, as shown at 1. These pockets are made wide enough to admit of the projection 2 sliding in



**Fig. 45.**

easily; when the bar rests on the bottom this projecting piece is opposite the recess cast in the pocket to receive it, and is driven home by the bent iron 3. This iron or

wedge is a plain piece of wrought-iron  $1\frac{1}{4}$  inch wide by  $\frac{1}{4}$  inch thick, bent as seen, and driven down so that the bar is pressed close into the groove; by leaving this wedge standing  $\frac{3}{4}$  inch out at the top it can be quickly knocked out and the bar loosened instantly. This is a very quick method, and only requires a long bolt here and there along the length to make it equal, in strength, to the other. Another advantage where pockets are cast to receive the bars is shown at *H*, as on a pinch wooden bars may be substituted for iron ones and made fast with wooden wedges.

#### FLASKS MADE OF WOOD.

Where wooden flasks can be profitably used, good white-pine should be chosen to make them of, as it outlasts any other kind and keeps its shape best. Ordinarily they may be made up to 3 feet square out of 2-inch lumber; beyond that size and up to 6 feet it is best to use 3-inch. Many firms go to great expense in dovetailing the joints,—a very bad method too, as the vent blazes out at the joints of the dovetail, and the flask is rendered useless in a very short time. A much better plan is to let the ends into the sides about  $\frac{1}{2}$  inch and nail them firmly together, after which a  $\frac{1}{2}$ -inch bolt can be passed through each end *in the inside*. If the flasks be long, additional bolts may be passed through in the middle. Greater dependence can be placed on the bolts than on any system of dovetail or spikes.

I have seen many plans for preserving the joints of wooden flasks (which, if unprotected, soon burn away), and in most cases the supposed cure has proved worse than the disease; but should it be considered worth while to protect the edge (and I am satisfied that it is, where the flasks are in constant use), have strips of cast-iron made  $\frac{1}{4}$  inch thick and the width of the lumber, with pins cast on. Have these strips drilled with countersunk holes for screw-

heads, and set them hard down on a coat of thick metallic paint. This makes the joint between the iron and wood perfectly air-tight, preventing the gas from escaping, and consequently the flask is saved from burning. I have rigged flasks this way which have been in use every day for months without taking any harm from the blaze at the joint.

Another thing I would suggest, where wooden flasks are in constant use: have a boy, or two, if need be, to throw water around the flasks as they are poured; it pays in the end to do this. Sometimes, in shops where help is scarce and the crane untrustworthy, it is out of the question to make large iron flasks. In such cases let cast-iron ends be made with good bolting surface for the wood to bind against; have also here and there a cast bar to which the side must be firmly bolted. These precautions add very little to the weight, but serve to increase the strength and usefulness of the flask. Swivels or handles cast on plates can be bolted on the sides or ends, making them in every respect almost equal to the best iron flask.

#### HINGED FLASKS.

Although to show the substitution of hinges for pins in moulding-boxes is the primary object of this article, I was necessarily led into other important subjects in connection with their use. My experience has taught me, that in the majority of foundries all the ingenuity of the moulder is expended in devising methods that will enable him to mould nearly every large green-sand casting in the floor. This is generally done with the view of saving cost of flasks, and when only one or two such castings are needed, I believe it is the correct thing to do. But other reasons are advanced for this almost universal bedding-in system, the foremost of which is, that it is the safest plan to adopt

when the job to be made is one of great magnitude; and, while I partly admit the force of such a reason, yet I am fully persuaded that much better results are assured by adopting a system which can be made equally safe, and at the same time enable the moulder to examine and finish all the parts of his mould with equal facility. It is well known that very many large jobs having critical parts are made in dry sand or loam for no other reason than to secure a well-finished casting, which could not result if it was made in green sand by the ordinary methods, on account of the difficulty of reaching its remote parts. If such extra expense in the production of these castings can be saved, it must surely be folly to persist in such a course.

Enter almost any foundry and examine such castings as we are speaking of, and the ugly fact of smooth upper surfaces, and equally rough and unsightly lower surfaces presents itself. To particularize, let it be an architectural work or a foundry making casting for tool and engine work: what do we find? As before stated, all the ingenuity possible has been expended to have castings made in the floor, without separation of parts. Brackets are made in cores and rammed against the pattern, leaving in almost every case an unsightly mark, if not something worse; chipping faces and mouldings are pinned on loose, to be withdrawn after the pattern has left the sand, and as a natural consequence portions of the face of the mould are disturbed and fall into the bottom, or, worse still, are forced away when the iron enters the mould and rise to the surface. And yet, inconsistent as it may seem, the greatest care is taken with the very small surface which can be reached by the moulder to make that as smooth as tools and hands can make it; which, by the way, only shows up all the more by comparison the deficiencies of those parts of the mould which cannot be reached. This is seen more particularly on square and rectangular columns, having



two or more face sides, with panels and other ornamentation; lathe beds, foundations for engines, etc.

Some firms desiring quality rather than quantity partially overcome this difficulty by lifting out the sides of the mould, when practicable, on drawbacks, which are plates bedded alongside the pattern, and partings made where

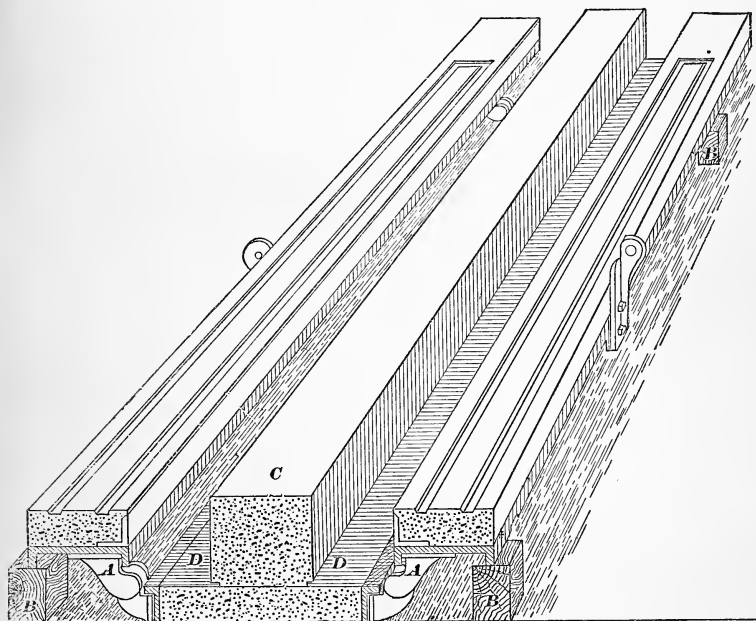


Fig. 46.

requisite. After the mould is rammed and the pattern taken out, then such portions of the mould as rest on the plates can be lifted away; but this method necessitates still more digging and ramming, and of course adds to the cost whilst it is oftentimes but a sorry makeshift.

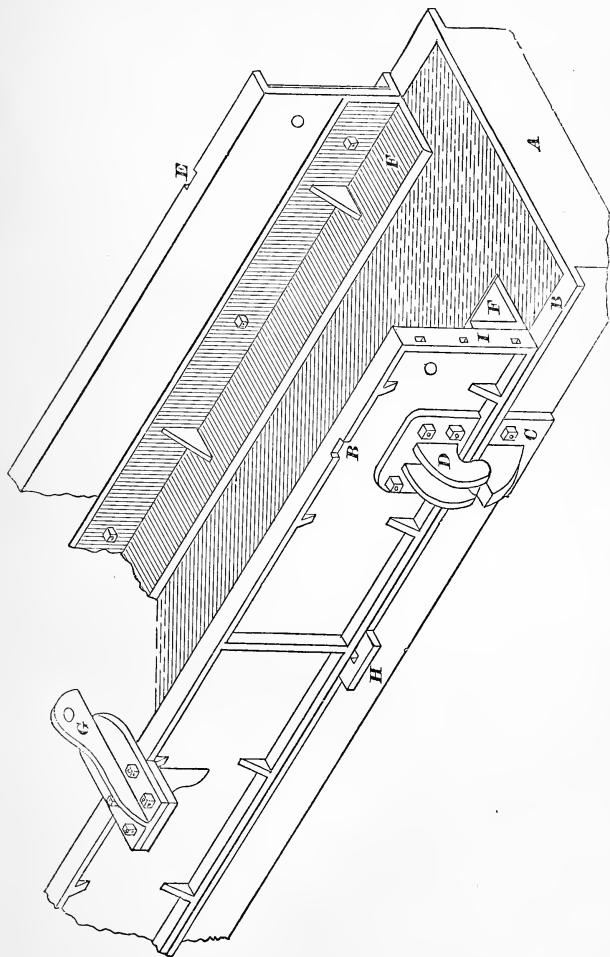
It is to facilitate the making of such castings that prompts me to suggest the use of hinges. Fig. 46 is a

perspective view of the mould of an ordinary square column, the dimensions of which are 18 inches  $\times$  18 inches  $\times$  12 feet, with panels on three sides. I have shown the mould as cut across at the first hinge, so that the working parts can be seen. The cheeks are thrown back on the hinges *A*, the top flange resting on lugs *B*, exposing the core *C* its full length, as well as the bottom of the mould *D*. It will be plain to any one having a knowledge of such matters that all the parts of such a mould can be treated with the same care, the result being a casting equally perfect all over.

At Fig. 47 I have shown the necessary appliances for making castings by this method, and as this view is drawn isometrically, the whole details can be seen at a glance much more readily than would be possible by the ordinary plan and elevation. Only a section of the sides is shown, but this is all that is needed for a clear understanding of the whole. I have selected a square column of the dimensions specified, because it is a class of work which is going on all the time, and serves well to illustrate the method suggested.

As I do not in this article propose to explain the details of moulding such a casting, I shall confine myself to the subject of hinges and the securing of the flask. The bottom flask *A* is shown longer than the cheeks, as it is supposed to be a fixture in a foundry exclusively engaged in this work. It is best to have such a bottom flask made with deep sides well down in the floor, and good stiff cross-bars bolted across; such a bottom flask serves to make ordinary columns or beams and girders in, the cope of course being made to correspond with flange at *B*, to which it can be bolted or clamped, thus saving both time and expense of weighing down. It is on just such a flask that these sides rest. The lower half of hinge *C*, into which the upper half works, serves the same purpose for the

regular cope when the bottom is being used for ordinary work; but in this case, when the cheeks are being used,



the cope can be pinned or iron slides bolted on to fit the recess shown at *E*. At *F* is shown the lifting-plates

secured to the cheeks. These plates serve the double duty of stiffening the cheek as well as carrying the sand, and may, of course, be taken into consideration when the mould is being bound together. By referring to *G*, it will be seen how the cheek is turned on its hinges, and without giving dimensions it will suffice to say that one or more of these lugs may be used, according to the length of the cheek, and also that they must be made with leverage sufficient

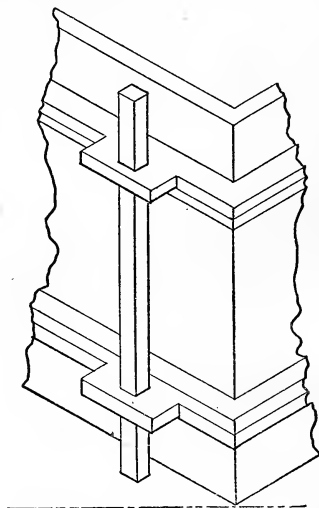


Fig. 48.

to turn backward and forward easily. The lug shown at *H* is for binding purposes. Let as many of these be cast on the bottom flange, to correspond with similar ones on the cope, as may be considered necessary for effectually securing the mould when closed. Holes must be cast in these lugs large enough to admit a strong bar reaching from one to the other—as shown at Fig. 48—and wedged firmly between the bar and cheek. Sometimes it may not be required to use any ends to the job in hand; if so, bolt

holes cast in the sides at each end can be utilized when the way is clear, for the bolt or provision can be made for bolting on loose ends as seen at *I*, Fig. 47.

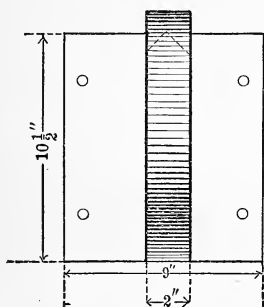


Fig. 49.

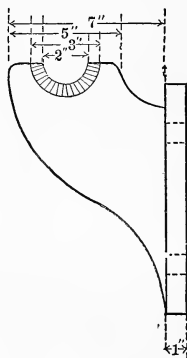


Fig. 50.

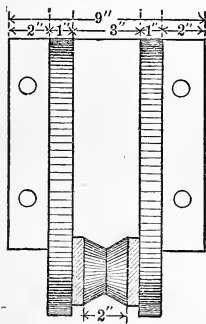


Fig. 51.

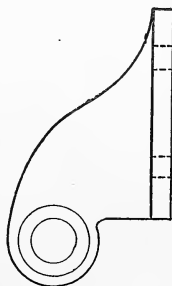


Fig. 52.

Should it be required to lift away the end as well as sides of the mould, this may readily be done by continuing one cheek round the ends to meet the other, or carry one

half on each; but if the job in hand be too unwieldy for such a method, as for instance tanks, hot-wells, cisterns, etc., of large dimensions, then, of course, separate cheeks can be made and turned back on their own hinges. To bind such ends provision can be made to bolt them to the cheeks when they are turned into place, or they can be treated the same as directed for the cheeks.

At Figs. 49, 50, 51, and 52, I have shown front and side elevations of both halves of a hinge suitable for the job described, with figured dimensions. This hinge is certainly the best as well as the cheapest that can be made, requiring no machinist work on it whatever; it is ready for use as soon as it leaves the sand. It is an absolute fit, cannot get out of order, and must therefore commend itself especially to foundries having no machine-shop. In conclusion, a hinge like this can be almost universally applied on ordinary work where the lifts are not too deep, or the parts of the mould too high to clear as it closes on the circle. It will save considerable to a firm using large numbers of top and bottom flasks.

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## FOUNDRY OVENS.

To properly locate a foundry oven is a very important item in foundry construction, for many reasons.

Too frequently we find that no attention has been given this subject until the foundry has been built, and then it is placed in one corner of the shop, thereby limiting the floor-space considerably, as well as making that particular spot very undesirable to work near during the warm months.

When it can be done, which is nearly always, it is best to have the oven outside, so that the doors will come even

with the inside of the wall, and in such a position as will permit a *straight* track to be laid directly under one or more of the cranes.

Another important consideration is what kind of an oven to build. I must say it would seem that very little attention is paid to this part of the subject, for, go where you will, you find that the universal idea is to have a hole of some kind, with a very indifferent carriage, requiring ten times the help to move in and out that it ought to, on account of the disgraceful roadway provided for it to travel on.

The same may be said in regard to the methods of firing such ovens, "any way" being considered "good enough," providing the cores or moulds are dry "some time."

The thought that, by a judicious arrangement of these things, both time and money, as well as considerable annoyance, might be saved to all concerned, does not enter the mind of the originator; and so he pursues his way blindly, supposing that he is saving money for the firm by withholding the cost necessary for alteration.

When an oven is to be built, care should be taken that it will meet all the requirements of the shop, both as to size and equipment.

Should an oven be required for a very small foundry, it is just probable that one or more of the very excellent rotary ovens now on the market will suffice, and be as cheap as anything which could be erected by the owner; but should it be that the amount of cores required are but few and small, a very cheap and handy device is to make cast or wrought iron sides and back the required width and height, the sides to be provided with slides at suitable intervals on which to rest the shelves. The top must be provided with a hole having a raised edge, on which a piece of stove-pipe may be fitted; the front must be hinged on full size, so as to expose all parts of the oven at once.

An ordinary fire-pot, with provision for draught underneath, can be set down in the floor and the oven set over, or the whole may be built within the plates, as shown at Fig. 57.

Extemporized ovens of this class are very useful, even in large foundries, sometimes, especially when small cores are needed through the day. They save the annoyance and loss caused by opening the large ovens, thereby allowing heat to escape, materially retarding the drying of the moulds.

For large foundries something more elaborate is necessary. If the business of the firm is a special one, with the same routine of work every day, it is well worth the time to consider what is needed to facilitate the rapid handling and drying of the cores and moulds.

The kind of furnace and its position, the place for the damper, and how to use it to get full duty from the fuel, are subjects worthy of consideration; also, how to regulate the damper in order to allow of the free exit of the vapor made during the process of drying, without interfering with the legitimate draught required to bring out the best results from the fuel used. These and kindred subjects should interest the moulder whose aim is to excel in these things.

If the oven is intended for jobs that will require more than one night to dry them, it will be proper to set the furnace or furnaces so as to allow of easy access without disturbing the doors and allowing the heat to escape. To meet this requirement, pits must be made, at the most convenient places outside the oven, to communicate with the inside by a fire-place, which can be built of fire-brick, either level with the floor or as much above as will allow of easy access from inside as well as outside. The regulation bearers and grate-bars can be used in the construction, and a front erected on the outside with doors after the manner



of an ordinary boiler-furnace. The pit in this case should not be less than 18 inches below the grate-bars, with ample room on all sides for firing and cleaning.

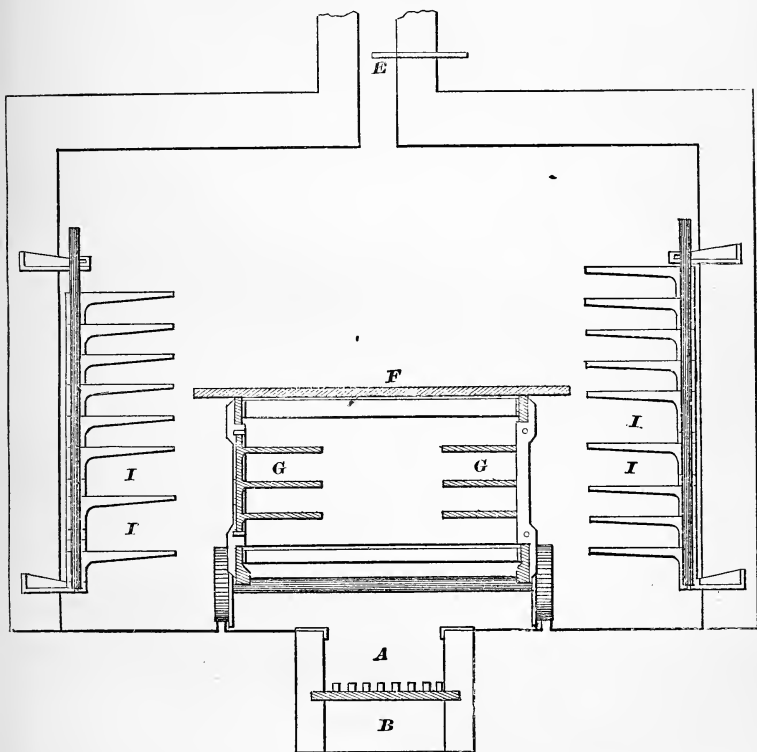


Fig. 53.

For an oven 12 feet by 10 feet, and 10 feet high, one such furnace will suffice if its dimensions are 4 feet by 3 feet, and 1 foot 8 inches deep. For rapid drying in larger ovens another furnace will invariably be required.

One great objection to this method of firing is that the

heat is not evenly distributed, some of the moulds or cores being in a semi-green state, whilst others are burnt so much as to be almost useless. To overcome this, recourse has been had to several ingenious methods to secure a more even distribution of the heat. One is to build flues which pass under the floor only in some instances, and others have continued the system along the walls and roof.

I remember when we thought all trouble of the kind above mentioned would cease after we had laid down a perforated floor; but, as in the former case, it was a comparative failure, inasmuch as we did not obtain the maximum amount of heat, nor was it evenly distributed; the extra heat at the end nearest the fire burnt out, and destroyed the castings so much as to make the arrangement almost valueless.

For all ovens where one night's firing is all that can be allowed, the method shown in the accompanying figures is the most effective as well as the cheapest, because, whether one or more furnaces are needed, they can be so placed as to be equidistant from the walls all round, thereby giving an almost uniform heat all through, at least as near as is practicable with open fires. I shall not dwell here on the possibilities for heating where there are good supplies of natural gas at a cheap rate; but it will be clear to all that the advantages which such offers ought to be made the best of.

Neither is it required at this writing that I should enter into a description of all the elaborate systems of drying by the use of hot air and superheated steam: these methods are only to be thought of where there is not only the demand for such immense outlay, but likewise the necessary genius to adopt them. I have no doubt whatever that if our foremen founders were better posted in such matters and able to make themselves understood, employers would be led to make vast improvements in their working plant, as well to their credit as to their profit.

In laying down an oven track be sure and have it as wide as the oven will allow; this gives stability, and allows for a good-sized carriage, which is a desideratum. But a good carriage is terribly marred by having an insufficient roadbed.

The best roadbed for an oven is made by good longitudinal timbers crossed by 12-inch by 4-inch I-beams—wrought-iron—on which the ordinary steel rails can be bolted. Ovens should not be made any higher than is absolutely necessary; the fuel needed to heat this extra space being so much wasted.

Where there is to be continuous firing, either hard or soft coal, of a medium size and good quality, may be used; but if all the coal needed is to be put on at once, then it is preferable that hard coal only should be used.

I would here say that it pays to have a man of more than the common run of intelligence to look after the firing of foundry ovens; much may be saved by such a man. He will acquaint himself with all their peculiarities, especially how to meet the various changes of the wind, etc., which of course affects the draught very materially, a full knowledge of which will enable him to guard against a very common occurrence,—either that the cores or moulds are not dried sufficiently, or that they are burnt so as to be useless.

By a careful observation as to the condition of the cores every morning, he will be able to modify his fire to suit the amount of drying to be done. If he finds that the walls and upper surfaces of the cores are covered with moisture, he will at once know that there has not been a sufficient allowance of draught made for the escape of the vapor; but he knows also that if he should open his damper too much to meet this evil, he encounters one equally as damaging, which is, that too free an egress for the vapor will carry along with it the heat also; the fires will burn too rapidly,

and the result will be even worse than before. He will take a middle course as near as possible.

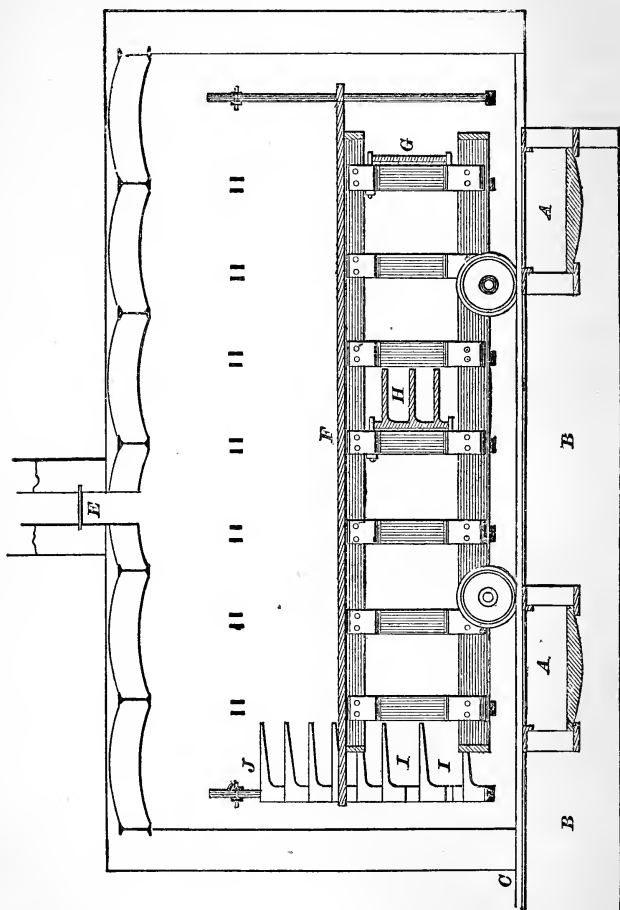


Fig. 54.

These are only some of the things which will come under the observation of a good man in such a position; his use-

fulness will manifest itself in countless other ways, always proving the advisability of preferring such a man, even at an advanced rate of wages, to men of only ordinary calibre.

The oven and carriage shown in the accompanying fig-

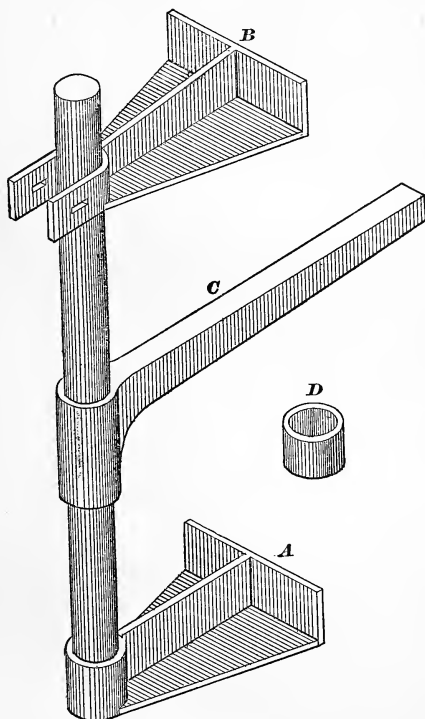


Fig. 55.

ures were built for the production of column cores, round and square. I desired that none of the principles herein set forth should be violated; it was my aim to occupy as much of the space as was practicable without in any sense marring the usefulness of the oven for any other purpose for which I might require it in the future.

The dimensions are 16 feet wide, 25 feet long, and 12 feet high; the walls are 16 inches thick, with roof composed of arches springing from seven 12-inch I-beams.

Figs. 53 and 54 are end and side sectional elevations of oven and carriage racks, etc.; Figs. 55 and 56 are views of details.

This oven is heated by two furnaces, *AA*, Figs. 53 and 54, which are 4 feet long, 3 feet wide, and 16 inches deep, respectively.

A continuous flue *BB*, Figs. 53 and 54, commencing 6 feet

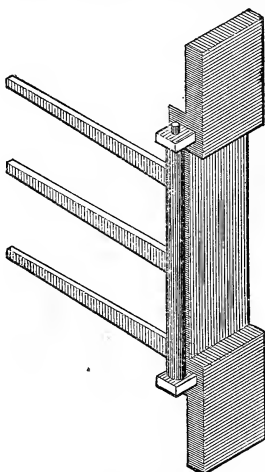


Fig. 56.

from door at *C*, Fig. 54, the same width as the furnaces, and 3 feet deep, running the whole length of the oven and out at the other end, supplies the draught, the damper being in the chimney at *E*.

The damper shown regulates combustion admirably, and allows for the minimum amount of coal to thoroughly dry all the cores up to 12 inches thick, without in any sense injuring such as are smaller.

The carriage, as will be seen, is a plain one, put together in sections, and travels on a track 7 feet 10 inches wide; its length is 20 feet, and it stands 2 feet 2 inches from the floor; the side supports and upper frame, made in sections also, raises the platform, or table, *FF*, Figs. 53 and 54, 6 feet from the floor; this platform is 23 feet long and 9 feet

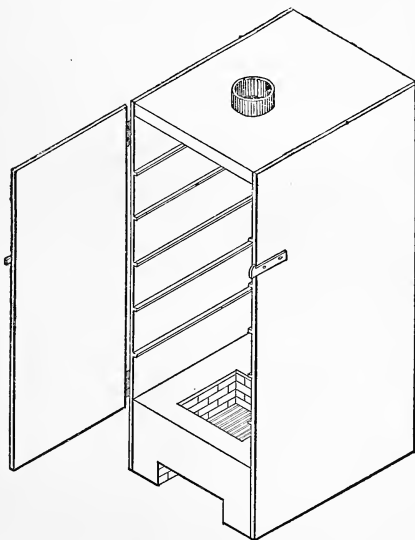


Fig. 57.

4 inches wide, made in sections, with edges and one side planed true, and bolted firmly on the upper frame so as to form a perfectly even and smooth surface, on which almost any kind of rectangular core may be made by the use of a pair of sides and ends only.

The uprights which support the table may be utilized for carrying cores by casting holes in them, through which eye-bolts may be secured. In these eyes racks may be made to turn either to the inside, as shown at *G*, Figs. 53

and 54; or they may remain parallel with the carriage, as seen at *H*, Fig. 54; or brought outwards, as necessity occurs.

An isometric view of the rack is shown at Fig. 56.

Not desiring to limit the width of the oven by building in the walls stationary rack fixtures,—which are never the right distance between,—I succeeded in contriving a rack which answers admirably. As will be seen, the whole consists of nine fixings on each side of the oven, built firmly in the wall, parallel and straight with each other; in the projecting ends of the bottom fixings a cup is cast, in which rest the 9 bars 3 inches in diameter and 9 feet long, held in position above by other fixings, built in the wall, with the projecting ends open, provided with a key-way with which to secure the shaft after all the arms have been slipped on.

The whole arrangement will be seen at a glance by carefully examining Figs. 53 and 54, and still more plainly by referring to Fig. 55, *A* being the bottom and *B* the top fixings spoken of.

*C*, Fig. 55, shows the arm, and *D* is a bush used to raise the arms to allow of a larger core being inserted between them, as shown at *I*, Figs. 53 and 54.

It must be understood that the bar is stationary, so that any of the arms can be turned out of the way at any time without disturbing anything which may be above or below. It will be readily seen that when all the arms, both on walls and carriage, as well as the upper and lower levels of the carriage, are in use there is certainly not much room lost; and when it is remembered that all that is needed to make a clear oven for other classes of work is to lay all the arms against the wall, as seen at *J*, Fig. 54, and strip the carriage of its upper rigging, one feels recompensed for the extra expense incurred in fitting up an oven after this manner.

And really I do not consider there is anything extraordinary in the expense of such an oven, for there need be



no machinist's help in the whole job; for allowing that proper clearance is given in all the parts described, everything can be lifted out of the sand and set into place without further preparation.

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## CRYSTALLIZATION AND SHRINKAGE OF CAST-IRON.

BEFORE entering on the subject proper of this article, it is important that we consider for a while the nature and properties of cast-iron. Such a course will, I think, help to clear away much of the apparent mystery which seems to cling to the subjects of crystallization, contraction, shrinkage, and warping of castings.

There is no valid reason for supposing that much if not all the trouble and anxiety which the founder experiences on account of warped and broken castings cannot be obviated, and the whole matter brought under absolute control. But the moulder will never control this very important branch of his business until he steps out of the beaten tracks made for him by his predecessors in the trade, and determines to acquire the knowledge that will enable him not only to mould from the pattern given him, but also to detect the faults in its design, and take such precautions as will insure success in the end.

Again, no one believes that the moulder who is ignorant of the nature and properties of cast-iron can be thorough at his business, nor need ever such a one aspire to anything more than being a mere machine at his trade. Hundreds of moulders are absolutely ignorant of the modes of producing cast or pig iron, and therefore it cannot be expected that such will be able to meet the numerous emergencies which from time to time beset them. It is for their

benefit, principally, that we take a brief survey of its manufacture.

The ores from which iron is smelted are found all over the globe, the chief kinds being: 1. Carbonate of iron, including spathic ore, which is found in thin plates or scales; clay ironstone, and blackband ironstone. 2. Magnetic iron ore. 3. Red hematite, specular or red iron ore. 4. Brown hematite, or brown iron ore. The magnetic ore gives the richest yield of metal—about 73 per cent when pure. It is found all over Europe, in Canada, and in the States of New Jersey, Pennsylvania, Virginia, etc. This ore is usually

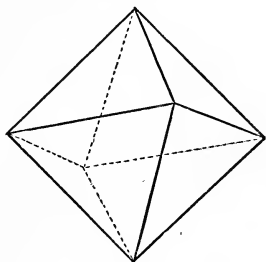


Fig. 58.

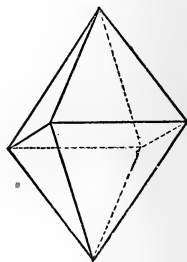


Fig. 59.

smelted with wood charcoal, this being the cause of its superiority, there being no sulphur in the fuel. Red hematite ore is also very rich in iron, giving about 70 per cent by weight. This ore is found in the Isle of Elba and other parts of Europe, especially Whitehaven and Ulverstone, England. Brown iron ore is a very important ore in England, and is much sought after by Germany and France. Carbonate of iron is known as spathic when it is found comparatively pure and crystalline, and as clay ironstone and blackband when earthy and impure. The spathic ore is found in great quantities in Prussia and Austria, and is in great demand to yield the spiegeleisen required in the Bessemer process of making steel. To give some idea of

the large percentage of impurities contained in some of the ores, I append an analysis of the clay ironstone, Blackbed mine, Yorkshire, England :

Protoxide of iron.....	36.14
Peroxide of iron.....	0.61
Protoxide of manganese.....	1.38
Alumina.....	0.52
Lime.....	2.70
Magnesia.....	2.05
Carbonic acid.....	26.57
Phosphoric acid.....	0.34
Sulphuric acid.....	trace.
Bisulphide of iron.....	0.10
Water, hygroscopic.....	0.61
“ combined.....	1.16
Organic matter.....	2.40
Insoluble residue, chiefly silica and alumina.....	25.27
	<hr/>
	99.85
	<hr/>
Metallic iron, per cent.....	29.12

This extraordinary amount of impurities in the ores necessitates considerable preparation prior to smelting in the blast-furnace. One method is to break the ore into small pieces, and mix along with it small coal. The pile, which may contain a thousand tons or more, is lighted at the end and allowed to slowly burn or roast (as it is usual to term it) for about a month, or until the whole has undergone calcination. Special kilns or calcining furnaces are also used for this purpose, the waste gases of the blast-furnaces being utilized as fuel. The process of calcination separates from 30 to 50 per cent of these impurities from the ironstone, besides effecting certain changes in the chemical constituents of the ore, which greatly facilitates

the process of smelting. Rich and comparatively pure ores are not subjected to calcination.

The proportions of materials necessary to smelt a ton of pig-iron will naturally vary according to the nature of the fuel and ore, but the figures given below are sufficiently near for illustration : 2 tons of calcined ironstone,  $2\frac{1}{2}$  tons of coal (about 800 lbs. of which is required for the hot-air pipes and blowing engine), and from 1200 to 1600 lbs. of limestone.

Blast-furnaces for the production of pig-iron are neces-

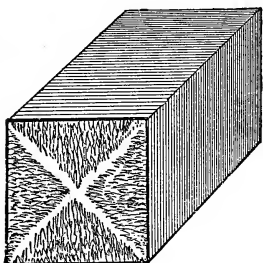


Fig. 60.

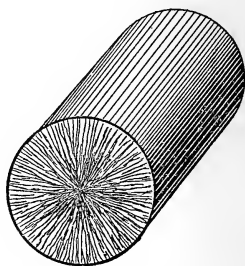


Fig. 61.

sarily of large diameter, and are built from 40 to 100 feet in height; the charges are fed at the top, consisting of alternate layers of the materials mentioned in such order as will best secure perfect combustion of the fuel and steady melting. Where hot air is used for blast, it is heated to from  $600^{\circ}$  to  $1000^{\circ}$  F., and enters the furnace through tuyeres arranged somewhat after the plan of a foundry cupola. When the furnace is successfully working, the clay of the ironstone unites freely with the limestone, and forms a slag or cinder, which is allowed to run off at suitable intervals; the oxide of iron at the same time gives up its oxygen to the fuel, and the metal falls to the bottom of the furnace. When sufficient metal has accumulated, it is tapped

and run into moulds formed to receive it, such moulds being the form of the pigs as we see them in our foundries.

The metal produced contains from three to five per cent of carbon, which it absorbs from the fuel, and it is this percentage of carbon which gives it the quality of cast or pig iron, as distinguished from wrought-iron and steel. Owing to the great heat required to reduce the ores in the blast-furnace, the iron is never obtained free from the elements remaining in the ores after calcination, such as silicon, sulphur, phosphorus, manganese, and in some cases arsenic, titanium, copper, chromium, etc., according to the ore used.

These impurities insinuate themselves into the cast-iron produced, in a greater or lesser proportion, according to the way the furnace is working; and a perusal of the analysis of Lake Superior pig-iron (charcoal), given below, will show to what extent this occurs:

Iron.....	93.34
Combined carbon.....	{ 0.38
Graphite.....	
Silicon.....	2.28
Sulphur.....	0.03
Phosphorus.....	0.10
Manganese.....	0.17
	<hr/>
	99.69

The carbon in pig-iron is always found in the two forms, combined and graphitic, but varies in its proportions according to the variety of the iron; the grayest iron having almost all of its carbon in the uncombined or graphitic form, whilst the hard, white irons have it almost wholly combined; but the amount never exceeds from 3 to 5 per cent in whichever form it may exist.

The difference in color, strength, hardness, fusibility, etc., of cast-iron depends upon the relative proportions of these two forms of carbon, varied by the influence of the

above-mentioned elements, which are always present in some degree or other. We thus have gray, mottled, and white iron, or, as they are commercially classified, No. 1, No. 2, No. 3, and forge iron. The No. 1 is the darkest gray, and contains the most graphitic carbon, as seen by the fracture, which is largely granular, and presents numerous graphitic planes or scales. When these abound, the iron will be found weak, with very little tenacity, and only suitable for light ornamental work, stove-plate, and all thin castings requiring little or no finishing. This iron, when melted and in the ladle, lacks the brightness exhibited by some of the higher numbers, however high its temperature may be; and, should it be allowed to cool, it will be observed that a scum or kish rises to the surface, composed of graphitic carbon, evidencing the inability of the metal to hold as much carbon in solution whilst at a low temperature as it does at a greater heat. When kish appears on the surface of the metal it is rendered unfit for use, as castings run with such iron present an unsightly appearance, being covered with a thick coat of plumbago.

No. 2 presents a more regular appearance in the fracture, the crystals are smaller, the color is a lighter gray; it is also harder and stronger than No. 1, and when in a molten state it does not exhibit the same tendency to kish as it cools. This iron is esteemed the most useful for general purposes.

No. 3 contains less graphite than No. 1 or No. 2, is less fluid when melted, but is much stronger, as it is more compact and dense; the crystals are still smaller and the color lighter than No. 2. This iron is suitable for heavy structural work.

The higher numbers up to white iron are designated forge irons, and are serviceable for puddling. Sometimes the pig will solidify partly as gray and partly as white, the crystallization having commenced in patches, but not spread-

ing through the mass before it solidified. Such iron is called mottled pig, and it may be used in conjunction with other irons in heavy castings which call for great strength and closeness of grain.

Certain kinds of gray iron, rapidly chilled after fusion, become white or mottled; the amount of combined carbon increasing, whilst a corresponding decrease of graphite takes place. On the other hand, some kinds of white iron, slowly cooled after fusion, show a separation of graphite and a corresponding diminution of the quantity of combined carbon; and according to Ackerman (a great authority on these subjects), "long-continued maintenance at a yellow heat is sufficient to change white iron into gray."

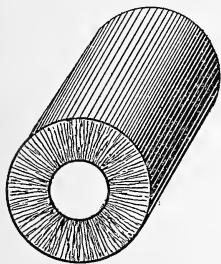


Fig. 62.

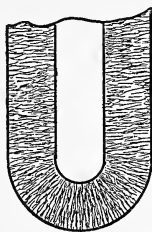


Fig. 63.

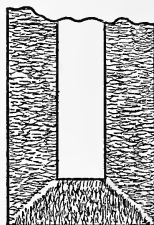


Fig. 64.

As cast-iron changes from the molten to the solid state it crystallizes, the form of the crystals being either octahedral, as seen in Fig. 58, or rhomboidal, as in Fig. 59. These crystals always arrange themselves in the casting with their principal axes perpendicular to the surface through which the heat has passed during the process of solidification.

It is a noticeable fact that slow cooling produces the largest crystals: this should suggest to the founder the propriety of pouring large castings with metal at as low a temperature as will allow of a correct impression of the

mould being taken. By following this rule the crystals will be smaller, on account of the more rapid solidification of the mass, and consequently additional strength will be imparted to the casting, by virtue of the greater compactness of the iron.

The appearance of the fractured surface of broken pig-iron is not always to be taken as a sure indication of its quality. It is pretty certain, however, that when the fracture shows a uniform dark gray, with strong metallic lustre, it indicates toughness; whilst, again, dark, leaden-colored irons, lacking lustre, with spots of mottle running through, will be weak and unserviceable. A light gray with strong luster indicates strength and tenacity, but a light gray without lustre will invariably be found hard and brittle, and still more brittle as it approaches a grayish white.

The founder, most assuredly, has many kinds of iron to choose from, the strength and fluidity of which will be according to their composition and mode of production. Cold-blast iron from the same ores is stronger than if produced by hot-blast. Iron which contains sulphur in small quantities is strengthened, whilst phosphorus has an opposite influence, decidedly weakening the iron, although it gives great fluidity when melted. Silicon, if present in iron above a certain quantity, weakens it; and if the proportion be large, makes it hard and brittle. Manganese, almost always present in pig-iron, tends to produce whiteness, as well as to make it more brittle. The strength of cast-iron is diminished by annealing.

When we consider the great change brought about in the nature of iron by the introduction of these elements, we discover the difficulties which beset the founder in meeting successfully all the demands made upon him for just the correct mixture for every casting he makes. When selecting iron for castings which have to resist impact, such as hammers for forges, etc., it is best to select from among



the No. 3 irons such as show a close, tough texture; this in conjunction with good scrap which shows a small crystal in the heavier fragments will answer the purpose well, especially if the pig is chosen from different brands; for it must be remembered that better results accrue from a mixing of brands than when one brand alone is used, the mixed brands being stronger than the average of brands taken separately.

Steam-cylinders and all castings demanding a clean, hard face when finished must be made from very compact brands of gray iron, hardened by a plentiful admixture of scrap, such as mentioned above. For such castings always avoid using iron which shows a large percentage of graphitic carbon in the fracture with large crystals, as it is sure to

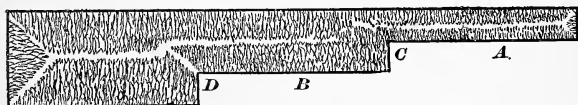


Fig. 65.

give trouble on account of the heavy scum arising from it in the mould. When practicable it is best for this class of work to run the mixed iron into pigs, and remelt for the casting; this improves the tensile strength of the iron, and gives it greater density.

Although much depends upon the experience and judgment of the founder to obtain the required degree of fineness and strength, yet it must be conceded that the strength of a casting may suffer deterioration from faulty designing with respect to the arrangement of its several parts, considered with regard to the influence its shape will have on the metal when it passes from the liquid to the solid state.

As before stated, cast-iron assumes the crystalline form when solid, and it is an established fact that the crystals

arrange themselves in a certain position in all castings, the tendency being with their principal axis perpendicular to the sides of the casting, or, in other words, they lay lengthwise and perpendicular to that part of the mould through which the heat passes; they are not always as regular and well defined as shown at Figs. 58 and 59, but they incline to that form, nevertheless.

By referring to Fig. 60, it will be seen how the crystals arrange themselves in solids of that class; the rays indicate their position in all solids of equal dimensions. The heat passing out at a uniform rate on every side gives four distinct systems of crystals, as it were, forming a junction at lines across the corners. This point of junction must of necessity be more or less imperfect; in fact, experience proves such to be the case; consequently the part where these several systems of crystals meet will be weak always. The weakest parts in this case are indicated by the diagonals; crystallization commencing first at the outside, and the process of solidification being uniform in every direction, must result in just such an arrangement of the crystals as is indicated by the figure.

What has been said with regard to crystals arranging themselves with their principal axis perpendicular to the sides, is verified by the solid shown at Fig. 61, a round shaft, the rays of which are seen to radiate from the centre; nor does the insertion of a core, as in ordnance, in any sense interfere with their position. (See Fig. 62.)

It will be remembered it was said that rapid cooling produced the smallest crystals. Figs. 61 and 62 will serve to illustrate this part of the subject. All solids have their largest crystals in the centre, gradually diminishing in size towards the circumference, caused by the almost immediate solidification of the outer parts; the inner mass taking longer to dissipate its heat through the gradually congealing metal.

It is this which causes cannon cast in the ordinary way to be spongy or porous in the bore, the only remedy for which is to bring about equal rates of cooling, by introducing a current of either cold air or water into the arbor or barrel upon which the core is made; by so doing unequal crystallization is obviated, and the metal made uniformly dense all through.

Cylinders for hydraulic purposes are made as shown at Fig. 63 in preference to Fig. 64, for the simple reason that the flat surface on the bottom of the core, with a corresponding flat surface on the bottom of the cylinder, as seen at Fig. 64, causes an arrangement of the crystals which produces lines of weakness from the outer edge of cylinder

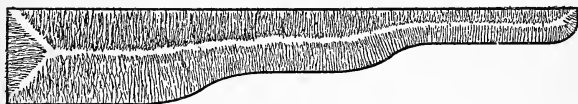


Fig. 66.

to the angle of core. This evil is prevented by adhering to the curved outline, as seen at Fig. 63.

Fig. 65 will serve to explain the evil effects of abrupt changes in the outlines of castings. The thinnest part *A* cools first, followed by the part *B*, the crystallization of which taking place after *A* is comparatively solid, forms a weak spot at *C*; because, as before stated, the crystals pack themselves in the same direction as that which the heat takes in passing from the molten iron to the outer surface.

Obeying this law, they must detach themselves more or less at these points of junction. Of course the same result occurs at *D*; in fact, all castings whose outlines present these sudden changes of conformation must deteriorate in strength; for, whether we see the checks or not, it is cer-

tain they exist in a greater or lesser degree. The simple remedy in this case is shown at Fig. 66, which represents a solid of the same bulk, so changed in its outline that the planes of weakness are reduced to a minimum.

Figs. 67 and 68 will aid in arriving at a true estimate of the superiority of curved lines, to give the maximum amount of strength for a given area of section. They may be taken for sections of wheel-arms with mid-feather, or as columns. At Fig. 67 the crystals are seen to arrange themselves perpendicularly to the sides and ends of the webs, giving weak lines at each of the inner angles.

How changed the scene when we look at Fig. 68; by simply rounding off the outer angles, and substituting a curve for the sharp angle at the junction of the webs, we obtain a continuous figure, presenting an unbroken outline, perpendicular to which the crystals arrange themselves with comparatively no interruption whatever.

In order to a clear elucidation of the laws of crystallization, and the consequent lines of weakness resulting therefrom, it will be necessary to examine into forms other than round and square. Fig. 69 is a rectangular solid, and shows an additional line of weakness, running parallel to the upper and lower surfaces, and connecting with the diagonals.

It would appear that this casting is veritably split in halves along this plane of weakness, and such is really the case in a partial sense. Examine the broken castings on the scrap pile, and innumerable examples will be found to prove this assertion; for in some pieces cavities are formed in exactly such places as are indicated by these lines of weakness, revealing the last stage of crystallization in all parts of the fracture; and where this phenomenon does not occur, a careful examination of the top surface of the casting will show that the upper section has fallen down during the process of solidification, and left a correspond-

ing concavity there. It is here seen why we attach the riser or feeding head on all such castings; the idea being to maintain a communication with these central planes of weakness, and by a constant feeding of hot iron to this particular place, counteract, in some measure at least, the tendency to hollowness caused by the shrinkage of the mass during the process of solidification.

As previously stated, this tendency to fracture in irregularly shaped castings can be considerably modified by a judicious selection of brands of iron having the least



Fig. 67.

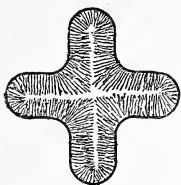


Fig. 68.

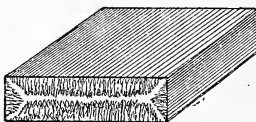


Fig. 69.

shrinkage. Broadly stated, gray iron shrinks the least; a perceptible increase of this quality manifesting itself all through the respective grades up to white iron, which is supposed to shrink the most. But it must be borne in mind that accepting the numbers of iron as graded at the different blast-furnaces, and basing our estimate of shrinkage on such grading, will oftener than not be found to be delusive, it being no uncommon thing to find No. 2 of one brand to shrink less than No. 1 of another. It would seem best, under such conflicting circumstances, to cast test bars of the several brands, and carefully note the shrinkage in each; such bars can also be tested for any other particular quality needed to bring the casting up to the required degree of perfection. This method enables the founder to

combine the several qualities required with almost absolute certainty.

Contraction is a subject which causes no small amount of anxiety to the founder, owing largely to the fact that little importance is attached to it by the designer or pattern-maker, who often insist upon having work made true to pattern, regardless of the obstacles they may have placed in the way of its accomplishment. Admitting the fact that

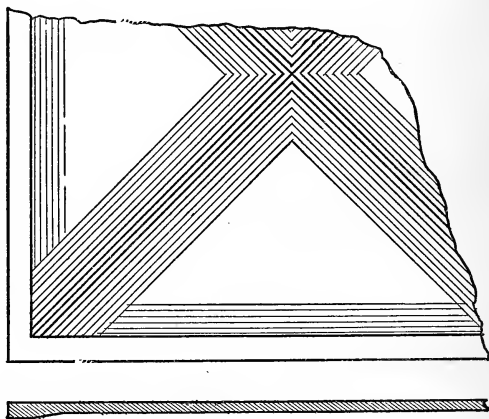


Fig. 70.

some attention should be paid to symmetry of design, yet we insist that this reason should never be allowed to usurp the place of strength and safety, as is too often the case. Many instances might be quoted where gross violations of the laws governing contraction are insisted upon, giving rise to all manner of contrivances to counteract the evil, much of which might be saved by a slight increase or decrease in the thickness of some particular part of the casting, to insure uniform cooling of all its parts.

It has often been said that if all the parts of a casting

were made equal in thickness there would be no trouble; but this assertion can be successfully combated by most founders of ordinary experience. Take the case of a flooring-plate, say  $\frac{1}{2}$  inch thick and 4 feet square, carefully moulded, and cast so that no part of the casting shall deviate from the thickness specified. Does such a casting, if left to take its own course, always come out true?

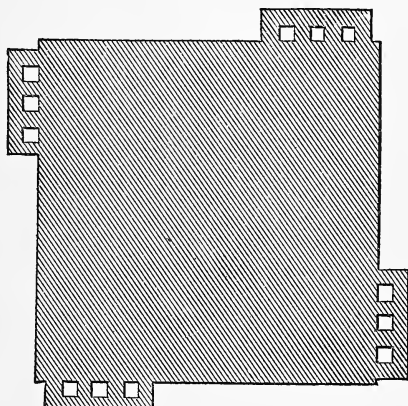


Fig. 71.

Hardly ever. This is only one of many instances which might be quoted to disprove such an assertion.

Let us take into consideration what occurs immediately after such a plate is cast. First, the surface under and over, as well as along the edges, almost instantly chills, from contact with the cold, damp sand; especially is this the case at the outer edges, which rapidly cool and contract, and, owing to the fact that the contraction must cease as the parts become cold, the outer portions cooling first, as just explained, are subjected to a continuous strain until the whole becomes cold and contraction ceases all over. Now, if this strain were equal on both sides, the plate

would remain straight; but such is not the case; the top cools first, on account of the heat passing more rapidly through the cope than it does into the floor, leaving the under surface to contract last, which it of course does by drawing the corners down, or, as is frequently the case, breaking the plate.

The lines of weakness shown in the solids are also lines of weakness in the plate, because, being the last to cool, the crystals assume larger dimensions, with a corresponding

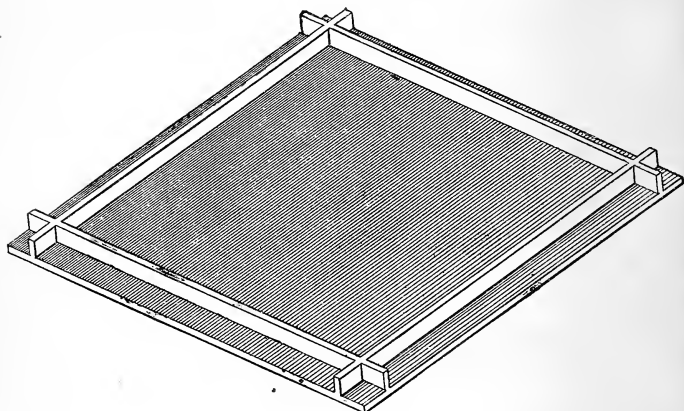


Fig. 72.

diminution in density, which means a loss of strength. To counteract this tendency to warping in plates, such as we have under consideration, cooling must be urged at such parts as would be last to set, so that equal rates of contraction may ensue. The parts which cool last in this case are indicated by the diagonals in the end section of Fig. 60; and should the plate be oblong, they will be as shown at end section of Fig. 69. By uncovering the sand from these parts immediately after pouring, taking care to keep the



outer edge well protected from the cold air, we may expect a true casting in most cases.

We will now look for a remedy in this case, that will not only save all the annoyance and trouble of cooling after the plate is cast, but will give us a casting comparatively free from internal strains.

We say the outer edge cools too quick: then increase the body of metal at that part. We say likewise that the diagonals cool too slow: then reduce the body of metal at that part sufficient to counteract the evil.

By adding  $\frac{1}{8}$  of an inch to the thickness at the edges, 2



Fig. 73.

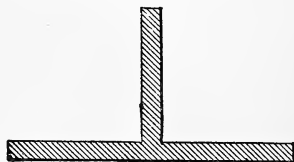


Fig. 74.

inches wide, chamfered so as to lose itself gradually in the surface, as shown in section at Fig. 70, and reducing the thickness at the diagonals  $\frac{1}{16}$  of an inch, working this out in every direction evenly and without abruptness, as shown by the rays in plan Fig. 70, the difficulty is surmounted.

Round disks or plates may be treated similarly. Should the plate be required 4 feet in diameter and  $\frac{1}{2}$  inch thick, let the edge be  $\frac{5}{8}$  inch thick, 2 inches wide all round, gradually reducing to  $\frac{7}{16}$  inch in the centre.

The proportions given will answer in the majority of cases for all such castings as we have been describing.

To insure good work of this kind, hot iron and rapid filling of the mould is indispensable. An arrangement of the gates for pouring large plates is shown at Fig. 71, which, when practicable, it is always best to adopt; for, by the

time the metal, entering each gate, has reached the opposite side, much of its heat has been absorbed by the cold mould, but it here receives an impetus from the hot iron which is just entering the mould at that spot. The metal, by this method of pouring, is given a rapid circular motion, which insures the correct filling of the mould with well-mixed iron at a *uniform temperature*,—a desideratum in this instance; for, as before stated, *difference in temperature causes variations in shrinkage*.

When ribs the same thickness as the plate are cast on, as shown at Fig. 72, the casting will be hollow on the plain side; the reason for which is, that the edges of the ribs set

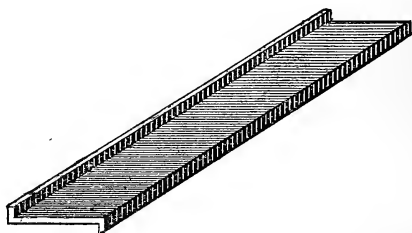


Fig. 75.

and contract, whilst the metal, at their junction with the body of the plate, is in a plastic condition. These edges then act as a prop or stay, to prevent the plain side from shrinking in a straight line; it must consequently either bend or break, the latter thing occurring very frequently.

If the outer edge be increased in thickness, as before directed, and the ribs made one fourth thicker than the body of the plate, this difficulty will be obviated.

Long plates, as shown in section at Fig. 73, always give trouble if ribs and plate are equal in thickness; by increasing the thickness of the ribs one fourth, straight castings will result. Suppose the plate at Fig. 73 be  $\frac{1}{4}$  inch, then the ribs would require to be  $\frac{5}{16}$  inch.

Beams similar to section Fig. 74 are always hollow on the plate side if the web is made the same thickness as the plate; the remedy suggested above will insure success in this case.

Fig. 75 shows a casting having one rib on each face at opposite edges; when such castings are made equal in thickness all over, the plate will be drawn convex along one edge and concave at the other. To put it another way, both ribs will be down at the ends. The remedy in this case is to increase the quantity of metal in the ribs 25 per cent, as before.

Fig. 76 is the sectional elevation of a casting, large numbers of which are made of various lengths in the several architectural works, for building purposes. The tendency in such castings is to warp hollow along the angle *A*. This is caused by unequal cooling; *B* and *C* cool first, and act as stays to prevent the part *A*, which is last to cool, from shrinking in a straight line. The edges *B* and *C* are consequently drawn round. It is customary to bare these castings along the angle *A* as soon as cast, with the view of preventing this; but this method rarely meets the case. A slight change in the form is all that is needed to obviate this trouble. Suppose the casting to be 1 inch all through in the original, as at Fig. 76: the alteration suggested is shown at Fig. 77 (when the casting must be moulded in the position as seen). The horizontal web is  $1\frac{1}{8}$  inches at *C*, and  $\frac{7}{8}$  inch at *A*, the vertical web being 1 inch all through in the pattern; this web will increase some in thickness at *B*, being the point of greatest pressure when cast. Consequently we have a gradual increase of thickness extending outwards, with a corresponding decrease at the junction of the webs at *A*.

When such castings can be moulded in the position seen at Fig. 78, the dimensions must be as figured,  $\frac{15}{16}$  inch at *A*, and  $1\frac{1}{16}$  inches at *B* and *C*, respectively. Square columns,

Fig. 76.

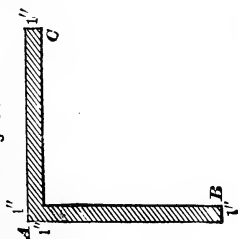


Fig. 77.

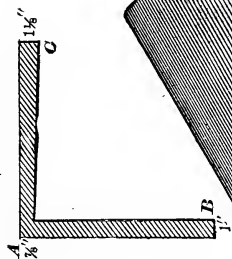


Fig. 78.

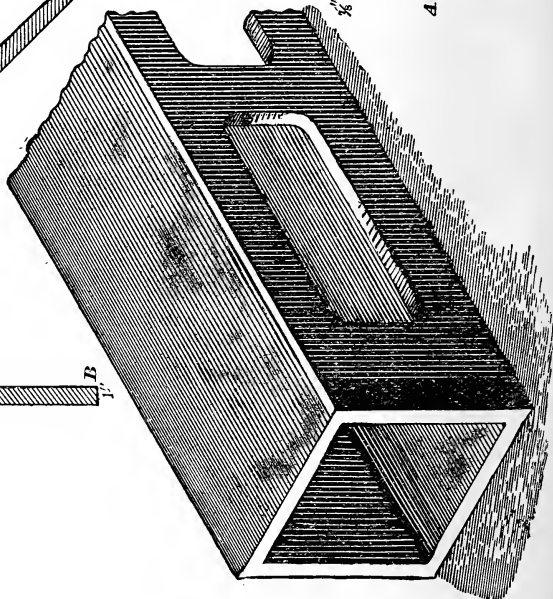
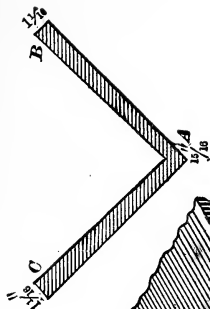
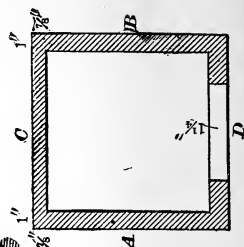


Fig. 79.

Fig. 80.



with openings along one side, shown at Fig. 79, if cast say 1 inch thick all over, will in all cases be drawn hollow on the side which is opposite to the holes, if left to take their

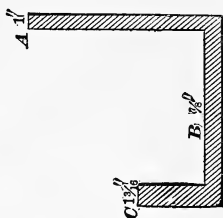


Fig. 82.

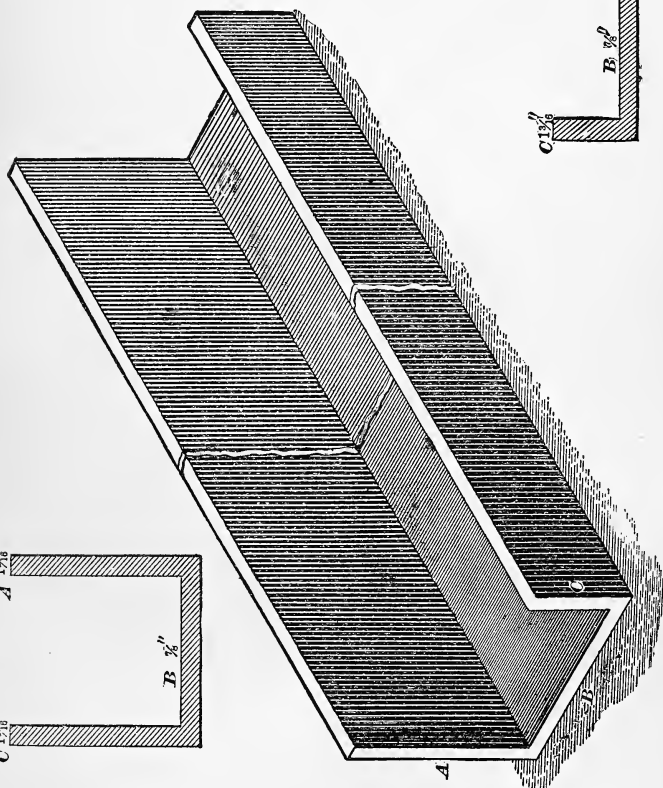


Fig. 81.

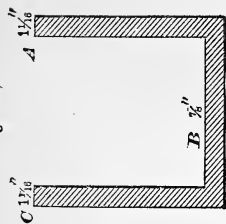


Fig. 83.

own course after being cast. The best method of bringing these columns out straight is to so proportion the thickness on all the sides as to produce equal rates of cooling. Fig.

80 is a section of 12-inch column, with figures showing the requisite proportions when the average thickness is to be 1 inch. Sides, at *AB*, 1 inch; top *C*,  $\frac{7}{8}$  inch; bottom *D*,  $1\frac{1}{4}$  inch.

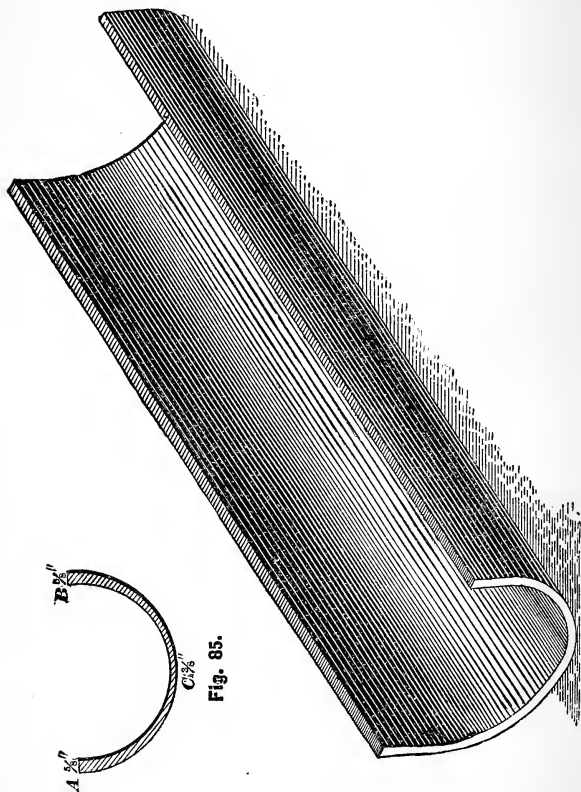


Fig. 84.

Fig. 85.

Long beams of the class shown at Fig. 81 will invariably warp hollow along the deep side *A*, with more or less tendency to hollowness at plate *B*. The view is that of a lintel 12 inches wide at *B*, with webs *A*, *C*, 12 and 6 inches

deep respectively, and 1 inch thick all through. To secure a straight casting, comparatively free from internal strains, the proportions marked at sectional elevation, Fig. 82, must be adhered to: plate *B*  $\frac{7}{8}$  inch, web *A* 1 inch, and web *C*  $1\frac{3}{16}$  inches. Should the webs be equal in depth, as seen at section Fig. 83, then the webs *A*, *C* must be  $1\frac{1}{16}$  inches, and the plate *B*  $\frac{7}{8}$  inch.

All castings of the kind shown in perspective, at Fig. 84, warp round on the top edges if equal thickness is insisted upon, from causes already explained.

The remedy is to follow the proportions as given at Fig. 85,  $\frac{5}{8}$  inch at the edges *A*, *B*, with a gradual reduction towards the crown at *C*, which must be  $\frac{3}{8}$  inch. These dimensions are given on the supposition that the casting is to average  $\frac{1}{2}$  inch thick, and the proportions will be safe to follow in all such castings, irrespective of size.

Round columns come crooked, more or less, if the heat escapes quicker on one side than it does on the other; as for instance, when the cope contains a very limited thickness of sand, or from exposure of one side before contraction has ceased. If these causes do not exist, and the core is set central, as at Fig. 87, these castings will come straight.

Sometimes cores are purposely set in the mould as shown at Fig. 86, the idea being to give a greater body of metal at the point of least pressure; this practice is to be condemned, inasmuch as it weakens the casting as well as causes it to become crooked.

There are some practices common to most foundries which cannot be too severely criticised. Columns are often made with heavy mouldings, and bases cast on them, to save trouble and time. This should not be done, as it endangers the safety of the casting; for not unfrequently castings thus made are found to have separated at places where abrupt changes have occurred in the outline. That

portion of Fig. 88 marked *A*, which represents a section of base having this fault, will give some idea of what is

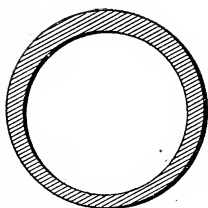


Fig. 86.

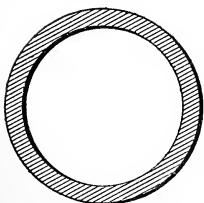


Fig. 87.

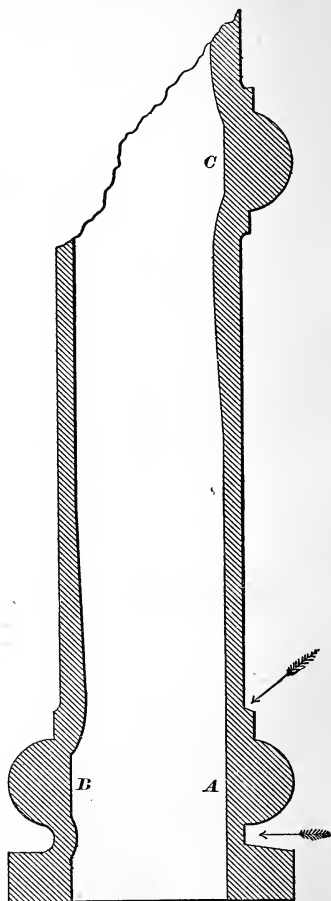


Fig. 88.

meant; the angles indicated by the arrows cannot be other than fractured, from the fact that crystallization of the



heavy portions takes place so long a time after the thinner parts are set. The correct method is to have the body of the column run even all through, with loose mouldings and base; but when, as is often the case, the builder or architect must be accommodated at short notice, a comparatively safe column may be produced by reducing the core

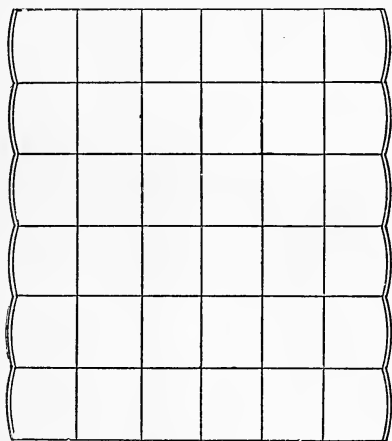


Fig. 89.

opposite the angles (taking care to round off the latter as seen), allowing it to gradually lose itself some distance away, as shown at base *B* and at moulding *C*. This allows the crystals to arrange themselves more uniformly in the mass, on account of the almost imperceptible change from a heavy to a lighter section of thickness.

Fig. 89 is an example of the folly of designing window-sashes, etc., with all or perhaps only two of the sides of greater sectional area than the inner ribs; the latter set and contract almost instantly, pulling at the outer frame whilst in a semi-molten condition, resulting in castings

similar to the somewhat exaggerated view given. The only remedy for this is to reduce the area of the heavy parts, distributing such reduction amongst the lighter ones, until a balance is obtained and equal rates of cooling assured.

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### PRESSURES IN MOULDS.

CAST-IRON in a liquid or molten state has the power to transmit pressure to every part of the mould into which it is poured; and each part of the mould—when it is full—sustains a pressure equal to the weight of a column of cast-iron, reaching from such part to the upper surface of the running basin.

Let a mould be prepared similar to the one shown at Fig. 90, page 89, which represents a plain bar 1 inch square and 12 inches long, with graduation-marks at each inch of its length. Now suppose iron is poured into this mould to the depth of one inch: it is plain that the weight of 1 cubic inch of iron is the pressure which the bottom surface of the mould must resist; and it is equally plain that the pressure on the bottom surface will be twelve times that amount when the mould is full. And because, as above stated, of the power of liquid iron to “transmit pressure in every direction,” each of the four sides of the bottom inch must bear the whole pressure, as long as the iron is in a liquid state.

The pressure at each graduation ascending decreases by exactly the weight of 1 cubic inch of cast-iron; thus, the pressure at each mark equals the weight of a column of cast-iron 1 inch square reaching to the surface. Let it be required to find the pressure at six inches deep.

Weight of 1 cubic inch, pound.....	.26
Depth, in inches.....	6
Pressure, in pounds.....	<u>1.56</u>

This shows that the pressure at  $\frac{1}{2}$  its depth equals a little over  $1\frac{1}{2}$  pounds. It must not be thought that because we have chosen a column having one square inch for its base, that the reasoning applies only in this case: the same

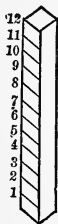


Fig. 90.

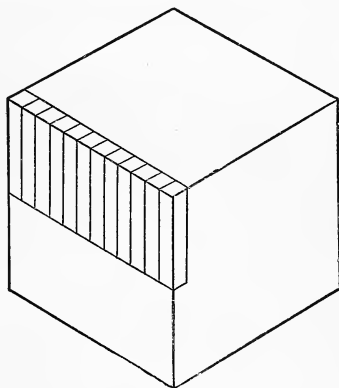


Fig. 91.

reasoning applies to every form or magnitude of base. Suppose the column to be 12 inches instead of 1, and 12 inches deep: the bottom surface of such a mould would have to resist a pressure equal to the weight of molten iron resting upon it, or 450 pounds; and the pressure against each square inch of the sides would be equal to the weight of a column of iron whose base is a square inch, and whose height is equal to the depth from the upper surface to that part of the side surface it may be desired to calculate for.

Let it be required to find the pressure at 6 inches deep, of the side 12 inches square.

It has been shown that the pressure at 6 inches deep for 1 square inch is 1.56 pounds. Therefore,

Pressure for 1 square inch, 6 inches deep.....	1.56
Multiplied by width of side.....	12
	<hr/>
Total pressure in pounds.....	18.72

This gives the pressure at 6 inches deep as nearly 19 pounds, or equal to the weight of 12 columns whose bases are each 1 inch square, and whose height is 6 inches, as seen at Fig. 91.

It must be understood that not only the surface of the mould, but every portion of the molten iron, sustains a pressure from the weight above it, and that this pressure is governed by the same law; in other words, every square inch of the surface of this cube is pressed by the surrounding metal whilst in a fluid state, and the amount of pressure which every square inch sustains is exactly the weight of the column of metal which stands above it.

The fact of the liquid iron coming to a state of rest after the mould is full, proves that these forces must be equal in any direction, and that, whatever be the pressure outwards on the side of the mould, the same force is being exerted in the opposite direction; so that every one of the 144 square inches contained in the square foot stands as it were on its own basis, exerting an equal pressure in every direction and on every side.

From the foregoing the following general law is deduced: "The pressure exerted at any depth below the surface is always equal to the weight of a column of cast-iron whose height is equal to the depth, and whose base is equal to the surface over which the pressure is extended."

It has been clearly demonstrated that every part of a horizontal surface, at the same depth, sustains the same pressure. I will now endeavor to show how the pressure is

exerted on the perpendicular sides of the mould in question. At Fig. 92 the side is divided into inches. Annexed to the several divisions on one of the sides is the amount of pressure in pounds exerted laterally at that particular depth from the surface when the mould is full. It is by the aid of this figure that I propose to show the method of finding the whole amount of pressure exerted on each side of the mould under consideration. This, clearly under-

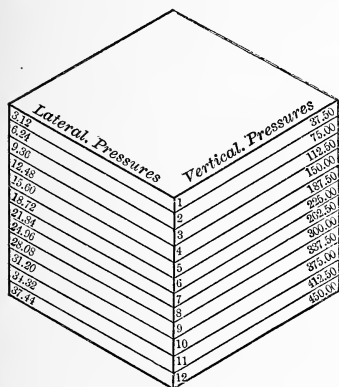


Fig. 92.

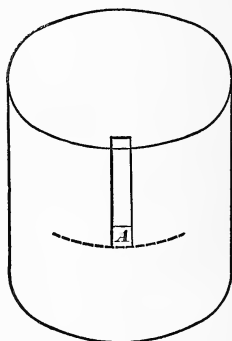


Fig. 93.

stood, will furnish a sufficient rule by which to obtain the correct sum of the pressure on the sides of any other mould, of whatever dimensions. (This figure also gives the amount of vertical pressure in pounds on the whole surface at the several depths indicated.)

At lateral pressures the amount for one inch in depth is 3.12 pounds (this means, of course, across the whole side), increasing by just the weight of an additional inch down to 12 inches, where it is seen to be 37.44.

Now, as this increase is seen to be uniform, one half of the depth must be the average pressure of the whole surface, and will be found at 6 inches.

To prove this, at 6 inches deep the pressure is 18.72 pounds—exactly one half of 37.44 pounds—which represents the extreme pressure at 12 inches deep. Now, take the pressure sustained at 7 inches, one below, and at 5 inches, one above, and we have 21.84 pounds and 15.6, respectively; add these together and we get 37.44 pounds, of which sum 18.72 pounds is one half. Or take the pressure at 8 inches deep, which is 24.96 pounds, and at 4 inches—the pressure at which point is 12.48 pounds—and we obtain the same result. If each of these points sustained a pressure of 18.72 pounds, which is the average pressure, we should have the same total.

The same reasoning will apply to all the points equally above and below the middle point, 6 inches; the pressure on each point below it exceeds the pressure at 6 inches by exactly as much as the pressure on a point equally distant above it falls short of the pressure at 6 inches, and therefore, on account of this mutual compensation, a general average is obtained.

It is clear that the total pressure on each side must be the whole 12 divisions multiplied by the amount of the average pressure, which is always found at half the depth of the liquid iron, and in this case is found at point 6 inches, at which point the pressure is 18.72 pounds. According to the above reasoning, the total pressure is the same as if this average pressure was uniformly diffused over the entire surface of the sides in contact with the liquid iron. Therefore :

Number of divisions.....	12
Multiplied by average pressure.....	18.72
	<hr/>
Total pressure on side.....	224.64

Again, it appears that the total pressure exerted on the perpendicular side—when the mould is full—is just the

same as if the side was taken for a horizontal bottom, and half the depth of the liquid iron rested thereon. Thus :

Side converted into a horizontal bottom....	144 inches.
Multiplied by half the depth.....	6 inches.
Total cubic inches.....	864
Weight of 1 cubic inch.....	.26
	<hr/>
	5184
	1728
	<hr/>
Total weight in pounds.....	224.64

Giving exactly the same results as previously shown. (I would say just here that this rule is absolute, and applies in all cases, whether the mould be solid, like the one we are discussing, or only  $\frac{1}{4}$  inch thick; as long as the iron is in a fluid state the conditions are the same.)

From these examples the following rule is deduced for calculating lateral pressure, where the mould has a flat bottom and perpendicular sides, and is simply filled open, as at Fig. 92. Find the number of square inches in one side below the upper surface of the iron in the mould, multiply this sum by the number of inches in half the depth of the liquid iron; the product will be the number of cubic inches contained in half the depth, the weight of which is equal to the lateral pressure on that side.

It matters not what form of bottom the mould may have. If it be horizontal and flat, and the sides perpendicular, the lateral pressure may be found by this rule, because the point of average pressure is always found at half the depth below the surface of the liquid iron.

Suppose the mould to be cylindrical (as seen at Fig. 93), 12 inches diameter and 12 inches deep. The point of average pressure is at *A*, which is one half its depth. To find the pressure on the whole side of such a mould, we proceed as per rule. Thus :

Circumference.....	37.69 inches.
Multiplied by the depth.....	12 inches.
<hr/>	
Total surface in sq. in.....	452.28
Half depth in inches.....	6
<hr/>	
	2713.68
Weight of a cubic inch.....	.26
<hr/>	
	1628208
	542736
<hr/>	
Weight in pounds.....	705.5568

It is seen that, according to the rule quoted, we have a pressure equal to  $705\frac{1}{2}$  pounds on the whole side of a cylindrical mould, 12 inches diameter and 12 inches deep, when such a mould is filled with molten iron.

To prove the accuracy of this rule, we will multiply the average pressure of one square inch down the perpendicular side into the total surface previously found. Thus :

Total surface in sq. in.....	452.28
Average pressure of 1 in. 12 in. deep.....	1.56
<hr/>	
	271368
	226140
	45228
<hr/>	
Total pressure in pounds.....	705.5568

This proves the lateral pressure to be the same as would be produced upon the bottom of a mould  $452\frac{1}{4}$  inches in magnitude, with perpendicular sides, and holding liquid iron to the depth of 6 inches.

A thorough knowledge of the increase of pressure in proportion to the depth will suggest the expediency of a corresponding increase of strength in the material used for



constructing very deep moulds. The pressure at the top being inconsiderable, very little strength is needed to resist it; but as the ratio of pressure increases with the depth, a good margin of strength is indispensable at the bottom. This will admit of a gradual decrease as the upper surface is neared. It is entirely owing to ignorance upon this subject that so many failures are made through lack of strength in the arrangements for securing moulds of considerable magnitude, or else, as is too frequently the case, the opposite extreme occurs, and time and material

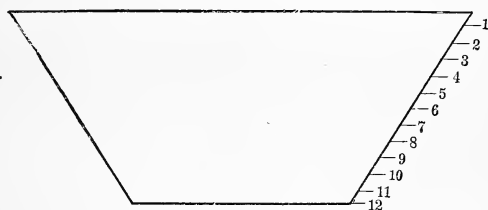


Fig. 94.

are lavished upon an undertaking sufficient for a piece of work of ten times the bulk.

The illustrations, so far, have been confined to moulds with horizontal bases and perpendicular sides, but in order to explain other phases of the subject of pressures it will be necessary to change the form of the moulds, pouring them (as in the former cases) level with the upper surface, or what is usually termed cast open.

Fig. 94 is the elevation of a mould whose sides are seen to slope outward. Its base is 12 inches square, and its perpendicular height is 12 inches. Fig. 95 shows another form of mould with the same dimensions for base and perpendicular height as Fig. 94. The angle of slope is also the same, but in this figure the inclination is inward. The lateral pressure on Fig. 94 must be the weight of liquid iron

resting upon it, and each point sustains a pressure equal to the weight of a column of iron immediately above it.

Now the lateral pressure on Fig. 95 must be just the same as at Fig. 94, because, as already demonstrated, liquid iron presses with equal force in every direction, and consequently each point of the lateral surface of Fig. 95 is being pressed upward with a force equal to the weight of a column of iron perpendicularly over it; therefore the rule given for ascertaining lateral pressures will apply in this case.

It must be well understood that the pressure on the bottom of all these moulds shown at Figs. 94, 95, and 96 is the same, because they are all of equal area and depth. The shape of the sides, or the quantity of iron which the mould contains, does not alter the conditions, namely, "that the pressure on the bottom is equal to the weight of a column of iron the depth of the metal contained in a mould, the sides of which are perpendicular from the base." Consequently the pressure on the bottom at Fig. 96 is exactly the weight of molten iron in the mould, because the sides are perpendicular to the base. But in the mould shown at Fig. 94 the pressure is less than the whole weight of liquid iron in the mould, while again at Fig. 95 it is greater.

Enough has been said to prove that cast-iron, when in a liquid state, transmits pressure equally in every direction, and also that the pressure produced by the weight of liquid iron is proportionate to its depth. If the explanations already given are thoroughly understood it will not be difficult to understand why molten iron (albeit so heavy) should have the property, in common with all other liquids, of finding its level. The discussion of this property in molten iron will enable us to more clearly elucidate the principle, or law, which governs upward pressure or "lift" in covered moulds.

For the purpose of illustrating this principle, we will suppose a mould like the one shown at Fig. 96, such mould to be filled by pouring the iron down the running gate *A*, which communicates with the mould at *B*. Casting moulds in this manner is the everyday experience of most foundries; it is therefore a well-established fact that the mould can be filled by this method. Now if the pressure at *B* (which is equal to the weight of a column of iron the depth and magnitude of the running gate *A*) was not

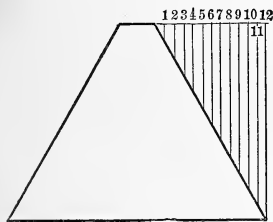


Fig. 95.

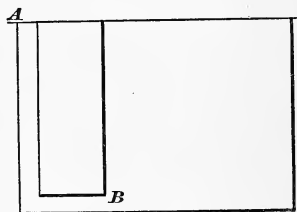


Fig. 96.

transmitted to every square inch of molten iron in the bottom of the mould, it would be impossible to fill it by this means. But such being the case, the mould gradually fills until the level of the runner is reached at *A*. This conclusively proves that the whole of the liquid iron in the mould is balanced by the one square inch contained in the running gate, the pressure of which is transmitted to every square inch on the bottom of the mould, and, pressing upward as well as downward, sustains the whole mass at a level common with itself.

In proving the existence of this force in an upward (as well as downward and lateral) direction, we shall undoubtedly solve the problem of how much weight is required to resist it. In other words, we shall discover how to secure the mould safely after it has been made and put together.

Fig. 97 represents the same mould as shown at Fig. 96. In this case it is covered with a cope or flask *A*. The running gate *B* is continued through the flask, and connects with the pouring basin *C*, into which the molten iron is poured, to find its way through gate *B* into the mould *D*. Now suppose the mould to be a cube of 12 inches dimensions, as at Fig. 96, and the flask combined with the runner box to be 12 inches deep, and remember-

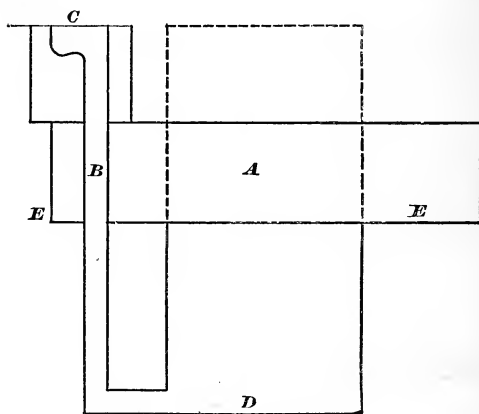


Fig. 97.

ing that the pressure arising from the weight of liquid iron is proportional to its depth, and that the pressure is transmitted in every possible direction, it follows that, because the increase of depth in the running gate is exactly double, the pressure inside the mould will be in the same ratio when the runner is full to the top of the basin. From what has been already demonstrated, it will be readily perceived that as soon as the liquid iron has filled the mould it at once begins to exert a pressure upward, against the cope, *A*, ever increasing until the running basin is full.

The amount of pressure or lift against the cope will be exactly the weight of a column of liquid iron whose magnitude is equal to the mould, and whose depth equals the depth of the running gate from the upper surface of the mould at *E* to the top of basin *C*, as shown by the broken lines. To prove this, let us again look at Fig. 96, where it has been clearly shown that the running gate has the power of sustaining all the iron contained in the mould at its own level, the reasons for which have been given. Now, applying the same reasoning to the question before us, we may rest assured that when the basin is full it will require as much weight to hold it there as it is capable of lifting up to its own level. This will be the case irrespective of the size of the runner or magnitude of the mould. To determine the amount of pressure arithmetically, "multiply the number of inches in depth below the top of running basin to the point at which the lift or pressure begins, by the number of square inches contained in the surface on which the pressure is exerted; the product of these numbers will be the number of solid inches of iron whose weight is equal to the pressure." Thus:

Depth from top of basin <i>C</i> to joint at <i>E</i> .....	12 inches
Total square inches of surface at <i>E</i> .....	144
<hr/>	
Total cubic inches. ....	1728
Weight of a cubic inch of cast-iron....	.26
<hr/>	
	10368
	3456
<hr/>	
Weight needed to balance pressure.....	449.28 lbs.,
or nearly 450 pounds.	

Should the surface against which the upward pressure is exerted be increased to 12 instead of 1 square foot,

the depth of runner remaining at 12 inches, the pressure would, of course, be increased 12 times, and a corresponding increase of weight would be required to balance it. The depth of mould below the lifting surface does not in any way affect the pressure against the cope; the pressure

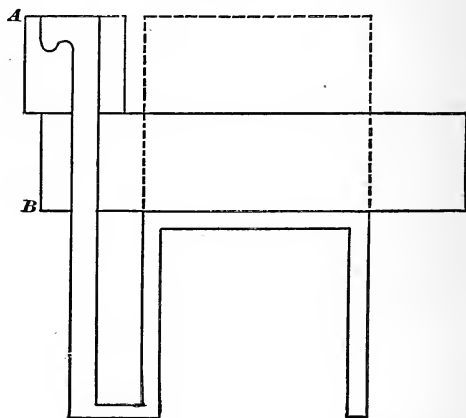


Fig. 98.

is just the same, whether the mould be one foot or one inch thick.

Fig. 98 is the sectional elevation of another kind of mould, being simply a square box one inch thick, with one open side. The inside forms a cube of 12 inches, consequently the outside dimensions are 14 inches square and 13 inches deep. It will be seen that the bottom of this box forms the upper surface of the mould, on which account the instructions given for Fig. 97 will serve for this, if *AB*, Fig. 98, equals in depth *CE*, Fig. 97.

Fig. 99 illustrates the same casting moulded in the opposite position (the bottom forming the lower surface), and will serve to explain some very interesting and instruc-

tive facts in relation to pressures in moulds. The pressure laterally and on the bottom is not any different than would be the case if the mould was a solid block (as in the examples already explained), but it is different with the cope, as the amount of pressure upwards is considerably increased; how much, I will proceed to show. I said that

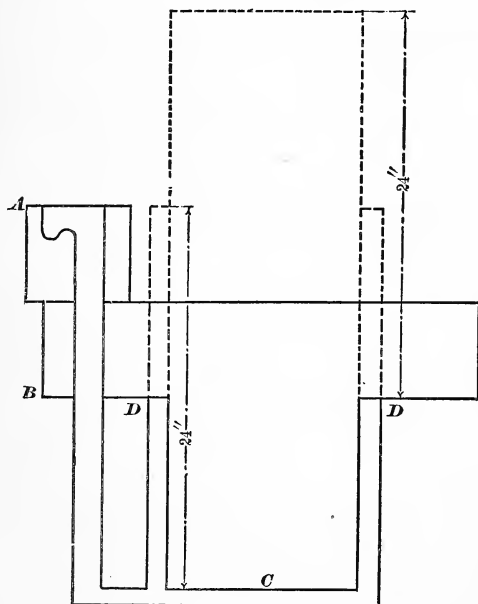


Fig. 99.

the inside formed a cube of 12 inches; now, allowing  $AB$  to be 12 inches deep, and  $BC$  to be 12 inches more, we find the full depth of pressure  $AC$ , Fig. 99, to be just twice as much as  $CE$ , Fig. 97 consequently the full pressure on the bottom of the mould acts with equal force on the under side of the core. In other words, the core has

taken the place of the molten iron which the runner is able to sustain, and, being so much lighter than the iron, will be borne upon its surface, if there is not sufficient weight added to make up the difference, and thus restore the balance.

As before stated, the pressure under this core is exactly the weight of a column of iron whose magnitude equals its bottom surface, and whose height equals the depth  $AC$ . The broken lines represent the weight needed to balance the upward pressure. An addition to the upward pressure commences at  $D$ , and the pressure from this point will equal the sum of one inch thick on all four sides of the core, multiplied into the depth  $AB$ . Thus, Fig. 99 :

Total square inches of surface at $C$ .....	144
Depth of $AC$ in inches.....	24
	<hr/>
	576
	288
	<hr/>
Total cubic inches.....	3456
Add cubic inches from $D$ to $A$ .....	624
	<hr/>
Total cubic inches.....	4080
Weight of a cubic inch of cast-iron.....	.26
	<hr/>
	24480
	8160
	<hr/>

Weight required to balance pressure.. 1060.80 lbs.

This shows that the weight need to balance the whole upward pressure exerted against the cope is about 1061 pounds, minus the weight of core and cope.

There are numerous contingencies in connection with this question, such as the methods of pouring, and flowing



off the metal at reduced heights, etc., to diminish the pressure; but of these I will speak further on, confining myself at present to the absolute laws which govern pressures when the molten iron is at a state of rest.

The mould shown at Fig. 100 is almost the same as Fig. 99, the only difference being that the core (which is supposed to be one cubic foot) is surrounded by one inch thickness of iron. These altered conditions will bring out

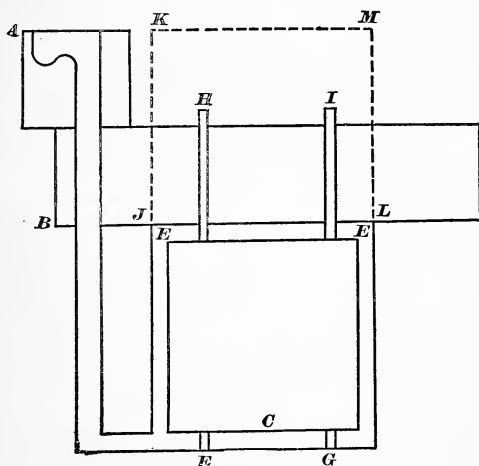


Fig. 100.

new ideas, and will aid materially in exploding some of the false notions which cling to this subject.

In the first place, it must be understood that the pressure under the core at *C* has reached its limit, immediately the molten iron begins to cover its upper surface at *E*, because as the iron flows over the core it acts as so much weight pressing downward, and by the time the runner is filled to the top of basin *A* the pressure downward is equal

to the weight of a column of iron 12 inches square, and as high as the runner basin *A* resting on it. Such cores usually rest on studs *FG*, and are held in position by others *HI*; now, the actual pressure against the top studs will in this case be the weight of a cubic foot of iron, or 450 pounds, and the pressure against the cope will be equal to the weight of a column of iron 14 inches square, the height of *AB*, shown by broken lines *JKLM*. It is evident from this example, that, to hold such cores in position, it is only necessary to provide for an upward pressure equal to the weight of the amount of molten iron they displace; also that the depth at which they may be placed from the surface of the running basin is of no consequence, so far as the upward pressure is concerned; but the general pressure will be proportionate to the depth, as has been already explained.

The class of moulds which next claim our attention are the spherical, including balls, shells, kettles, pans, etc., and the cylindrical, including cylinders, pipes, columns, shafts, etc., cast horizontally. To thoroughly understand the method of finding the amount of upward pressure on this range of work, it is important that the examples given on average pressure be clearly understood.

What has been already stated with respect to average pressure is the principle, which, generalized, must lead to a rule that will answer for every variety and shape of mould. As before stated, the various parts of any surface, whatever be its form, will be subject to pressures, depending on their depths below the upper surface of the running basin; all points at the same depth suffering the same pressure. There is a certain pressure or mean of all the various pressures to which the points of the surface are subject, and whatever this pressure be, it must be such that, if diffused over the whole surface, the total amount of the pressure on that surface will not be altered. If,

therefore, this medium pressure can be found, and the magnitude of the surface in contact with the liquid iron be known, the total pressure may immediately be obtained. To determine, therefore, the total pressure of any surface, "let the position of the centre of gravity of that surface be determined by the rules established in mechanics, and let its depth below the highest point of the liquid iron be ascertained, then multiply the number of inches in this depth by the number of square inches of surface against which this pressure is exerted; the product will express the number of solid inches of iron whose weight is equal to the total pressure."

I have shown at Fig. 101 the section of a mould for a cylinder 12 inches diameter and 1 inch thick, cast horizontally. A careful examination of this drawing will at once reveal the method of finding the amount of upward pressure in all such moulds. The highest point is the upper surface of the running basin *A*, and it is from this point that all the depths are measured. To find the pressure under the core, we must first ascertain the point of average pressure, which is thus found: Let the square *CDEF* be drawn around the core, and from *CDEF* draw lines to the centre; the point of intersection of these lines with the circle will be the point of average pressure. Lines drawn across the square at *BB* and *B'B'* give the rectangle *GHIJ*, whose weight equals the amount of pressure under the core.

To find the cope pressure, draw *KLMN*; the intersection of *KN* with the outer diameter at *O* gives the point of average pressure for the cope. A line drawn across *OO'* the width of the outside of the cylinder at *PQ*, and then vertically to the height of running basin, gives the rectangle *PQRS*, whose weight equals the amount of pressure under the cope. When these rectangles are obtained, they will in this case be found to measure 14 inches

by 7 inches for the cope, and 12 inches by about  $8\frac{1}{2}$  inches for the core. Therefore the whole pressure per foot in length would be obtained, thus:

FOR COPE.	
Width in inches.....	14
Depth     "     .....	7
Area in square inches.....	98
Length in inches.....	12
Total cubic inches.....	1176
Weight of a cubic inch.....	.26
	<hr/>
	7056
	2352
	<hr/>
Total pounds pressure per foot.....	305.76

FOR CORE.	
Width in inches.....	12
Depth     "     .....	8.5
Area in square inches.....	102
Length in inches.....	12
Total cubic inches.....	1224
Weight of a cubic inch.....	.26
	<hr/>
	7344
	2448
	<hr/>
Total pounds pressure per foot.....	318.24
Add amount for cope.....	305.76
	<hr/>
Total pressure cope and core per foot.....	624.00

The combined pressures per foot in length for a 12-inch cylinder, with the upper surface of the running basin 12

inches above the centre of the mould, is thus found to be 624 pounds, and, of course, that amount of weight is needed to balance the pressure on every foot. In other words, if the mould is 10 feet long, the whole pressure would be 624 pounds multiplied by 10, equalling 6240 pounds.

An important feature of this question is that, should the depth from the centre to the upper surface of the pouring basin be increased, the rectangle  $PQRS$  must be brought up to its level by adding the increased depth to  $R'S'$ , as shown by the broken lines. The increase of pressure under the cope caused by these altered conditions would be just three sevenths of the amount previously found, and a corresponding increase of weight would be needed to balance it. But these altered conditions do not affect the core, only in the general pressure all around it; for whilst additional depth creates more pressure, it must be remembered that this increase of pressure is exerted on the whole surface of the core, downwards as well as upwards; it must therefore remain stationary.

To put it otherwise, the amount of weight found to be necessary for holding down the core in this case is just what would be required if the mould was filled no higher than  $GH$ , for immediately the molten iron passes this point it begins to receive, in a downward direction, the same pressure as is produced on the cope upwards, which acts as added weight for increased pressure. Consequently it will be seen that the conditions laid down for securing the core are not affected by any increase in the depth after the points  $GH$  are passed.

The points of average pressure in spherical moulds are found by the same methods as shown for cylindrical moulds, by reason of which we can use Fig. 101 to demonstrate the principles involved; simply using the figures  $GHIJ$  and  $PQRS$  as elevations of cylinders, instead of



be observed that the weight of cope or core has not been taken into consideration; but this may be done when it is practicable to ascertain the exact weight, and allowance made accordingly. But when the weights can only be approximated, good judgment will suggest a wide margin on the side of safety.

Another item for consideration is the form of running basin used to pour the mould with. Figs. 102, 103, 104 will help to explain this part of the subject. It is very evident that if we pour a casting down a runner similar to the one

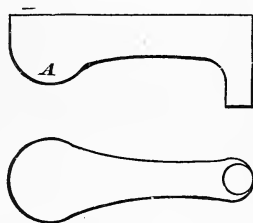


Fig. 102.

shown at Fig. 104, that the molten iron will enter the mould with a greater impulse than would occur if the basin shown at Fig. 102 was used, because of the accelerated force of the fall being exerted immediately down the runner; whilst in the case of basin at Fig. 102 this force is spent at *A*, giving time for the molten iron to mass itself *quietly* before entering the mould. If runner 104 must be used (as in some instances it must) sufficient extra weight must be added to meet the necessity. Runner 103 meets this case half-way, being a medium betwixt the two.

Being assured that pressure is proportionate to the depth, and that the depth is the height of the top of the running basin above the surface against which the pressure is exerted, numerous ways of reducing this pressure (and thereby saving labor in weighting) will suggest themselves, and

may with safety be adopted. Risers, or flow-off gates, as large and as numerous as practicable, may be placed at convenient parts of the mould, and the iron allowed to flow off at a lower altitude than the running basin. Suppose the height of basin to be 24 inches from the surface of pressure, and the risers flow off at 12 inches high, or one half; all else being favorable, it would be correct to base the calculation on 18 inches instead of 24 inches deep (this being the average between the two), and by so doing save 25 per cent of weight.

If the work in hand must have the whole pressure level with the top of running basin, make "assurance doubly



Fig. 103.



Fig. 104.

sure" by adding some to the depth when making the calculation. Thus, if the actual depth be 12 inches, call it 13 inches deep. This will give one-twelfth more weight than is needed to balance the pressure, and will be found to be a sufficient proportion of allowance in all ordinary cases.

The following table will be found useful to such as have not the time or inclination to study the subject of pressure. It is only necessary to find the depth and area of lifting surface, and the weight required to balance the upward pressure will be found opposite these numbers. The accompanying examples will explain the use of the table.



TABLE SHOWING THE AMOUNT OF WEIGHT NEEDED TO BALANCE THE UPWARD PRESSURE OF MOLTEN IRON IN MOULDS AT GIVEN DEPTHS AND AREAS.

Depth.	Area.	Weight to Balance Pressure.	Depth.	Area.	Weight to Balance Pressure.	Depth.	Area.	Weight to Balance Pressure.
Ins.	Sq. Ins.	Lbs.	Ins.	Sq. Ins.	Lbs.	Ins.	Sq. Ins.	Lbs.
1	1	.26	3	200	156.	9	20	46.8
1	2	.52	3	300	234.	9	30	70.2
1	3	.78	3	400	312.	9	40	93.6
1	4	1.04	3	500	390.	9	50	117.
1	5	1.3	3	600	468.	9	60	140.4
1	6	1.56	3	700	546.	9	70	163.8
1	7	1.82	3	800	624.	9	80	187.2
1	8	2.08	3	900	702.	9	90	210.6
1	9	2.34	3	1000	780.	9	100	234.
1	10	2.6	6	1	1.56	9	200	468.
1	20	5.2	6	2	3.12	9	300	702.
1	30	7.8	6	3	4.68	9	400	936.
1	40	10.4	6	4	6.24	9	500	1170.
1	50	13.0	6	5	7.8	9	600	1404.
1	60	15.6	6	6	9.36	9	700	1638.
1	70	18.2	6	7	10.92	9	800	1872.
1	80	20.8	6	8	12.48	9	900	2106.
1	90	23.4	6	9	14.04	9	1000	2340.
1	100	26.	6	10	15.6	12	1	3.12
1	200	52.	6	20	31.2	12	2	6.24
1	300	78.	6	30	46.8	12	3	9.36
1	400	104.	6	40	62.4	12	4	12.48
1	500	130.	6	50	78.	12	5	15.6
1	600	156.	6	60	93.6	12	6	18.72
1	700	182.	6	70	109.2	12	7	21.84
1	800	208.	6	80	124.8	12	8	24.96
1	900	234.	6	90	140.4	12	9	28.08
1	1000	260.	6	100	156.	12	10	31.2
3	1	.78	6	200	312.	12	20	62.4
3	2	1.56	6	300	468.	12	30	93.6
3	3	2.34	6	400	624.	12	40	124.8
3	4	3.12	6	500	780.	12	50	156.
3	5	3.9	6	600	936.	12	60	187.2
3	6	4.68	6	700	1092.	12	70	218.4
3	7	5.46	6	800	1248.	12	80	249.6
3	8	6.24	6	900	1404.	12	90	280.8
3	9	7.02	6	1000	1560.	12	100	312.
3	10	7.8	9	1	2.34	12	200	624.
3	20	15.6	9	2	4.68	12	300	936.
3	30	23.4	9	3	7.02	12	400	1248.
3	40	31.2	9	4	9.36	12	500	1560.
3	50	39.	9	5	11.7	12	600	1872.
3	60	46.8	9	6	14.04	12	700	2184.
3	70	54.6	9	7	16.38	12	800	2496.
3	80	62.4	9	8	18.72	12	900	2808.
3	90	70.2	9	9	21.06	12	1000	3120.
3	100	78.	9	10	23.4			

NOTE.—These weights are exclusive of cope, core, covering-plate, or whatever the pressure is exerted against.

## EXAMPLE 1.

It is required to find the amount of lift or pressure under a flask containing a plate 6 feet long and 4 feet wide. Depth from top surface of running basin to the surface against which the pressure is exerted, 12 inches, gates and risers adding 6 inches to the width of the plate.

## OPERATION.

Length of plate in inches.....			72
Width of plate in inches, including gates.....			54
			<hr/> 288
			360
			<hr/>
Total square inches of lifting surface.....			3888
	Ins.		Lbs.
Per table for 12 inches deep.....	1000	=	3120
	3		3
	<hr/>		<hr/>
	3000	=	9360
Per table for 12 inches deep.....	800	=	2496
“ “ “	80	=	249.6
“ “ “	8	=	24.96
	<hr/>		<hr/>
“ “ “	3888		12130.56

Making 12,130½ pounds, or a little over six tons, needed to balance the pressure. Suppose the cope to weigh 2000 pounds: this would give a sufficient overplus; and this proportion of overplus must in all cases be allowed, especially in the event of having to run up to the full head of pressure.

## EXAMPLE 2.

Required, the amount of weight to balance the pressure against a surface containing 1651 square inches; depth

from the top of running basin to lifting surface, 1 foot 9 inches.

			Inch.	=	Lbs.
Per table for 12 inches deep.....			1000	=	3120
“ “ “			600	=	1872
“ “ “			50	=	156
“ “ “			1	=	3.12
			<hr/>		<hr/>
“ “ “			1651	=	5151.12
			Inch.		Lbs.
Per table for 9 inches deep.....			1000	=	2340
“ “ “			600	=	1404
“ “ “			50	=	117
“ “ “			1	=	2.34
			<hr/>		<hr/>
			1651	=	3863.34
Add amt. for 12 inches deep.					5151.12
					<hr/>
Total weight needed to balance pressure....					9014.46
or a little over $4\frac{1}{2}$ tons.					

*Note.*—If risers of at least five times the capacity of the runners are set to flow off at four inches below the top of the running basin, the extra weight may be dispensed with, and the cope allowed as weight in the calculation.

In most cases, however, close figuring may be dispensed with by substituting another area or depth for the one in question.

For instance: “Suppose the pressure to be required for 975 square inches area, 6 inches deep,” 1000 may be substituted for 975, and the answer obtained at once. The error, being on the side of safety, can be readily allowed.

Or it might be required to find the pressure at 9 inches deep for 1200 area. Then 600 gives 1404, or one half of the sum required.

## CHILLED CASTINGS.

CHILLED castings ought to combine the maximum of strength with a hard wearing face. To insure these conditions, especially in car-wheels, the tread or outer surface of the rim should be chilled to whiteness, passing into a mottled iron, and from that to a soft gray in the interior of the wheel.

The irons used for these castings are certain brands of cold-blast charcoal, brown hematite, or specular iron; few, if any of the pure magnetites can be used successfully for the purpose. Especially is this the case with most of the No. 1 irons, which usually contain an excess of carbon in the uncombined state.

At the same time it is, we think, difficult to predetermine, from the chemical analysis of any pig-iron, whether it will produce good chilled castings or otherwise.

It must be admitted that certain mixtures of pig-iron will answer better than others, but what these mixtures are exactly, can only be ascertained by such founders as make the manufacture of chilled castings a specialty.

The succeeding article "Mixtures for Rolls," discusses the various difficulties which beset the founder when he essays to establish formulas, or mixtures which shall be considered as standard; and when, in addition to what is therein stated, we consider that a difference in the mode of working in the blast-furnace may change the nature of a metal which had previously given satisfaction, so as to render it absolutely worthless, we realize the imperative necessity of constant daily tests of the mixtures in use; such tests to be made at least one day prior to the cast. There is no doubt but that the mixing of the iron for chilled work is the most important as well as the most difficult part of the business.

The most that can be done by the founder who is entering upon this line of work is to select irons which contain a considerable portion of their carbon in a combined state, and which yield a strong, tough, fine-grained, bright gray, also such as exhibit a gray mottled fracture in the pig.

Spiegeleisen, in proper quantities, can be added to the mixture, if found too soft and too low in chill.

Certain proportions of Bessemer-steel scrap will impart strength as well as deepen the chill. Some say that by using Bessemer steel charcoal-iron may be dispensed with altogether; but I failed to elicit confirmation of this when the question was put to an eminent specialist, who said that, after repeated trials of mixtures composed of steel scrap in varying proportions with the best brands of anthracite pig, he was unable to produce a mixture which would meet every requirement, and consequently had continued the use of charcoal-pig exclusively.

Old car-wheels which have been made by a reliable firm may be mixed in proportions varying according to the grade of metal they are composed of and the depth of chill; in fact, such wheels, when the fracture shows a low percentage of mottle, with but a very thin film of chilled surface are in some instances the best mixture that can be obtained.

When iron of the exact grade and quality needed cannot be obtained, recourse must be had to a judicious mixing together of white irons with some of the dark-gray irons, the proportions of which can be ascertained only by practice and keen observation.

There are many excellent brands of charcoal iron in use for the manufacture of chilled castings, but none of them exceed in quality or produce better results than the "Salisbury." This conclusion is arrived at after careful and studious experimenting on my part, backed by the opinions of some of the leading manufacturers in the States.

## MIXTURE FOR ROLLS.

THE question is often asked by foundrymen, "What is the best mixture for rolls?" and again, "Why cannot we have a 'regular' set of mixtures, gotten up by some one who has had large experience in this class of work?" Go where you will, you are met by these inquiries, and (strange as it may seem) no answer comes—at least, none that is intelligible to the average moulder. Some have tried to give what purported to be the right mixture, made up of so much of "this," to so much of "that," supplementing the formula by saying that good rolls were made at such a place by the mixtures given. Again, you go into shops where they make a specialty of rolls, and ask for their mixtures, and naturally they shake their heads, and express by the look they give, as well as they could by a multitude of words, "Not much." Now this is very discouraging to the seeker for information; and yet it is not to be wondered at when we take into consideration the amount of labor and study which has been devoted to the subject by those engaged in the business; and it is not too much to say that even the best informed on the subject are very far from perfection, inasmuch as they are constantly called upon to change their mixtures on account of the variations in the different shipments of iron. To attempt to give a formula for universal adoption by saying, "So much of No. 2 to so much of No. 5, and so on," is sheer nonsense, for the simple reason that when you receive a consignment of iron from the furnace which was ordered to be No. 4, you will find that no less than three or four grades of iron have been shipped to you, making it utterly impossible to follow any prescription based on the number of the iron alone. The trouble can be overcome after this manner :

After first settling in your own mind what particular grade shall be called No. 1 and No. 6, with their intermediate numbers according to grade, you may then make from your own experience mixtures that will be intelligible to yourself, but would be useless to any one unacquainted with your methods of numbering. But this is not all that enters into the successful making of rolls, or anything else that requires special mixtures. If it were at all times profitable and convenient to use new iron, the business might soon be learned by adopting the method suggested above.

All foundrymen of experience are aware that large quantities of scraps (from broken rolls and other castings made from charcoal iron) accumulate and must be worked up, and it is right here that the skill and judgment of the mixer is put to the test; and I know of nothing which demonstrates the impracticability of making a set of standard mixtures more than the fact that whilst some of the scrap may be open-grained and very soft, other specimens will be perfectly white and brittle as glass; and yet some of our experts insist on their mixtures being correct, which tell you to put in a certain proportion of scrap. Again, it is common amongst moulders to say when a roll turns out too soft, or the opposite, "Oh, there ought to have been a little more 'car-wheel' in that mixture," or a little less "car-wheel," as the case might be; as if car-wheels were a something on which the greatest reliance could be placed for being always one thing in point of density or hardness. A little observation on these points will at once dispel this illusion, for whilst some wheels may be chilled almost 1 inch deep, others again will be found hardly touched with chill, and the iron all through as soft as lead almost.

Again, I would call the attention to this fact, that full reliance cannot be placed on the productions of our best

firms in this line of business. I have seen four rolls, all of the same dimensions, which came from a leading firm, no two of which were alike in density. One was almost condemned for being too hard, the softest being as much in fault the opposite way. I mention this to show that however much may have been accomplished in the way of mixtures, much still remains for the judgment of the mixer; for, as is well known, a judicious selection of scrap in large quantities will always produce the finest casting, and, if possible, new iron should never be used exclusively. Many may think that it would be easy to mix sufficient very hard grade new iron to neutralize a very soft one. This plan will never succeed. The result of such a mixture is always a pronounced mottle, large and unsightly; the white and dark patches seem never to have united. Such rolls last but a very short time, for as soon as they are put to use the soft parts crumble out, leaving the roll perfectly honeycombed. This proves the necessity of using iron in the mixture not too far apart in their nature and degree of density, and of choosing such grades as are the nearest to the mixture required. A good plan is to melt together your very hard and soft scrap, and run down into good-sized pigs, say 6 or 8 inches square. The reason for this is that where small pigs are made for charcoal scrap, the result is "white iron," which as a rule you do not want. All overflows from casts should be run in like manner, and covered over as soon as run. By adopting this method a great saving is effected.

I shall now proceed to give a few mixtures for different-sized rolls; and to make them intelligible to the reader it will be necessary to inform him what is meant by Nos. 3, 4, and 5, as the case may be. These several numbers represent the grades as arranged for my own convenience in mixing.

For instance, No. 3 means a close, even-grained, clear



bright iron, entirely free from the slightest trace of chill. This iron, if of a good brand, will be hard to break, and when broken will show a clean fracture straight across the pig. (I would here call the reader's attention to the fact that Salisbury charcoal iron forms the basis of these mixtures, being, in my opinion, the best iron for rolls.) By No. 4 I mean an iron very similar to the No. 3 in the centre of the pig; but about an inch from the edge all round it assumes a darker hue of a bluish cast, and much closer in grain, with a tendency to chill at all the corners. This iron will be still tougher than No. 3, but must have no trace of mottle in it. By No. 5 I mean an iron having the centre of pig the same grain as the 1 inch round the No. 4 pig, the rest being mottled, and having its surface chilled to the depth of  $\frac{3}{8}$  or  $\frac{1}{2}$  inch. By a faithful adherence to the descriptions of the numbers it will be easy to arrange the following mixtures, all of which I consider "standard," having used them myself with unvarying success. They are the result of a patient study of the subject, aided by an extensive series of experimentary practice. As will be seen, I give more than one mixture for the same-sized roll, which enables the mixer to regulate his mixture according to the iron he may have by him. It will also be observed that I describe the nature of the scrap used as well as the car-wheels; these are important items, and must be carefully noted; as, for instance, by "low" car-wheel, I mean such as have not more than  $\frac{1}{4}$  inch chill on the face; by "medium" car-wheel about  $\frac{1}{2}$  inch; and by "high," I mean such wheels as are chilled from  $\frac{5}{8}$  to  $\frac{7}{8}$  inch. The scrap I also distinguish by grades in a similar manner; and as scrap is made up of a miscellaneous lot of old iron, such as pieces of rolls, necks, etc., also such scrap as is made in the foundry, including all grades of hardness, it becomes imperative that the closest scrutiny should be made of such, assorting and grading it as directed. By "low"

scrap, I mean such as shows neither chill nor mottle. "Medium" is intended for all scrap which is mottled, but only slightly chilled ; whilst "high" means that which is deeply mottled, with considerable chill. By noting carefully these particulars, the table of mixtures given below will be intelligible.

These mixtures are so many pounds to the ton of 2000 lbs., and may be modified to suit circumstances, as, for instance, scrap may be substituted for wheel of the same grade, or *vice versa*.

	No. 3.	No. 4.	No. 5.	Scrap, Low.	Scrap, Medium.	Scrap, High.	Car-wheel, Low.	Car-wheel, Medium.	Car-wheel, High.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
For 10" and 12" rolls, with 5" and 6" necks	.....	1000	.....	1000	.....	.....	.....	.....	.....
Another.....	500	600	150	.....	.....	.....	750	.....	.....
For 15" rolls, with 10" necks	.....	940	.....	.....	900	.....	.....	.....	.....
Another.....	160	1350	.....	.....	.....	.....	.....	650	.....
For 20" rolls, with 11" necks	.....	1100	.....	450	.....	.....	.....	.....	450
For 22" rolls, with 17" necks	.....	920	165	.....	500	.....	.....	415	.....
For 25" rolls, with 11" necks	.....	600	.....	200	300	.....	300	300	300
Another.....	300	1100	100	100	200	200	.....	.....	.....

## PART II.

### *CORE-MAKING.*

---

#### CORE-MAKING.

THE initiatory branch of the moulders' art is core-making; and why such an important subject should be left so much in the background I am at a loss to understand. I consider it to be the foundation of the business, and feel assured that sufficient stress is not laid upon the importance of our apprentices learning that part of their trade thoroughly.

It is not uncommon to see good moulders placed at a great disadvantage from their inability to make their own cores. This should not be the case. Every moulder ought to be able to do this.

Let us first consider the material needed for core-making. To insure success in this department requires skill in the selection of the different sands and their several mixtures. Districts widely separated will vary considerably in this particular, according to the kinds of sand nearest to hand, and their suitability, price, etc. The city of New York and vicinity are fortunate in having unlimited supplies of beach or white sand, which enters largely into the mixtures for general work. Especially is it well adapted for small jobbing cores, being very fine and easily worked, and, after being burned in the casting, giv-

ing little trouble to clean. But in the country, where white sand is out of the question, on account of the cost for carriage, the river-sands are used instead, with slight variations in the mixtures.

The next in importance is the coarse, sharp, or, as it is by some called, fire-sand, on account of the resistance it offers to the high temperature of the molten iron. This sand is valuable also because, being so open in its grain, it permits the gases formed during the process of casting to escape freely, or, as is most commonly said and understood by moulders, "the air comes off good." But good as these sands are, they would be valueless alone, because, containing little or no clay,—as most other sands do,—they will not hold together by the regular method of dampening and ramming. Consequently, in order to utilize them, we resort to artificial means to bring them up to the proper consistency. The most common things used for this purpose are flour, molasses, clay, resin, and glue. There are many other things used, but, for all practical purposes, I consider the ones mentioned will meet all requirements.

Moulding-sand is also used in the core-mixtures, to help them up to the required stiffness, on account of its possessing in a great measure the elements lacking in the white and fire sands; but, on account of its finer nature neutralizing the good derived from the openness of the fire-sands, it must be used only for the purpose of stiffening, as before mentioned. Moulding-sand, so called, is that which is used for the legitimate purpose of moulding, as the filling of foundry-floors, sand-heaps, and, when suitably treated by the admixture of the necessary ingredients, for the facing of patterns. As previously stated, the kinds of moulding-sand differ according to the districts from which they are got; yet, as they are all chosen with the view of best suiting the work for which they are required, I think it will not be difficult to determine which is needed after

the enumeration of some of the most useful kinds and the particular virtues they possess.

The Albany and Waterford sands are chiefly valuable on account of their fineness, being graded from No. 1 up to the coarsest kinds. The No. 1 is used for the finest kind of work, such as stove, register, very light machinery, etc. But for the heavier kinds of jobbing and machinery work, the Jersey sands rank A No. 1, being of a tougher nature on account of the larger percentage of clay which enters into their composition. There are also three grades of this sand, the medium being the most useful. But, as this sand contains so much more clay, we need great care in its use. Its property of adhesiveness makes it valuable for the heaps and floor; but for the facing of patterns we have recourse to the mixtures before spoken of, these mixtures being required as well for the easier and safe working as for the purpose of conducting the gases from the surface of the mould. I shall say more on these subjects in their proper place, and shall now proceed with the subject of core-making, first giving a list of mixtures which I have proved to be the best for the work for which they are intended.

#### CORE-SAND MIXTURE NO. 1.

10 parts white sand, 1 part flour, with water sufficient to make it work easily.

No. 1 mixture is for small jobbing, round and square, and all cores not too large, and where the iron, in pouring, does not strike the core. A little water sprinkled carefully over the cores before putting into the oven will give a harder skin.

#### CORE-SAND MIXTURE NO. 2.

7 parts white sand, 3 parts fine Jersey moulding-sand, 1 part flour, with water sufficient.

No. 2 mixture is for cores requiring a little tougher sand, and will cling together better than No. 1, enabling you to bring up the edges good, and is suitable for small port-cores for cylinders, pumps, etc. Sometimes I have found it necessary to change these mixtures to suit intricate jobs having very thin cores in them, and difficult to vent. In such cases I have, after failure with mixtures Nos. 1 and 2, had recourse to the following, never knowing them to fail in cases where the proper precautions were taken to make and secure the vents.

#### CORE-SAND MIXTURE NO. 3.

10 parts white sand, 5 parts moulding-sand, 2 parts No. 1 mixture, 2 parts resin (ground very fine). Mix with water, and sprinkle a little weak molasses-water on cores.

#### CORE-SAND MIXTURE NO. 4.

Mix thoroughly, when dry, half and half river-sand and fire-sand, sift through a fine sieve; then to 15 parts of mixed sands add 1 part of resin,  $\frac{1}{2}$  part of flour, and mix with weak molasses-water.

#### CORE-SAND MIXTURE NO. 5.

8 parts fire-sand, 2 parts Jersey moulding-sand, 1 part flour. Mix with thick clay-water.

No. 4 is a good substitute for the "white"-sand mixtures. No. 5 is an excellent mixture for larger cores, and is the best dry-sand facing for any ordinary work, such as cylinders, pumps, etc., up to 40 inches diameter, requiring very little venting if thoroughly dried. It is also suitable for large pipe and other cores, for which the other mixtures are not suited, on account of the tendency of the white or river sand to melt or scab. Pipe-cores made of

No. 5 mixture will enable the moulder to gate or run his casting on the top—an absolute necessity sometimes where a sound casting is required.

I need not give any more mixtures for core-sands, as a slight modification of the above will enable the core-maker to meet all demands on his ingenuity.

#### LOAM MIXTURES FOR CORES ON BARRELS.

Where the loam must be made by hand, the mixture is 5 parts fire-sand, 2 parts Jersey moulding-sand,  $1\frac{1}{2}$  parts manure. Thick clay-wash to suit.

If ground in the mill, the ingredients will be: 7 parts fire-sand, 2 parts moulding-sand, 2 parts manure. Thick clay-wash.

The reason for the increase of fire-sand and manure is that the mill grinds the ingredients into a finer mass than they can be mixed by hand; therefore, to preserve the openness required, more fire-sand and manure are added; but care must always be taken not to grind the mass longer than is necessary to mix it well.

#### RIGGING FOR CORES.

Another important item in core-making is the rigging for securing, venting, transportation, etc., and to be able to make the best use of such tackle as may be on hand, as well as to get up new arrangements if actually needed. I have frequently seen immense waste of time and money caused by the elaborate nonsense of some would-be genius, who, if he had looked carefully into the job, would have been able to do it twice over with the rig he had around him, and in much less time than it took him to use the complications he had pondered out.

To begin with, we will take a very simple example—that

of a flat core 2 feet long, 1 foot wide, and 6 inches thick. Suppose it stands out of the mould at each end 3 inches; except at the ends, metal is supposed to cover the whole of the core. Now, all we have to do in this case is to secure the sand with rods both ways and take the vent out through the ends, as at Fig. 105. Such a core as this would require No. 5 mixture. Now, this is a very ordinary core to make, but, retaining the same width and length and changing the depth, we shall meet new necessi-

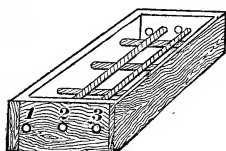


Fig. 105.

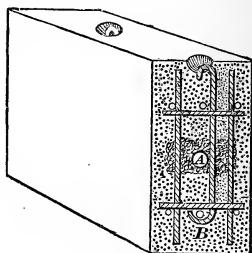


Fig. 106.

ties. Let us suppose our core to be 24 inches deep, and we find that we must tie our core in its depth as well as in its width and length. Better provision must also be made for carrying off the gas than is shown at Fig. 105, as the three holes, 1, 2, 3, will not be sufficient for that purpose. Allowing that we have nothing but rods to make our core with, we must put in two sets of irons, 6 inches from each end of the core, in the same manner as shown at Fig. 105, and also ram up other irons on end, to tie the core in its depth.

To lead off the gas, we either increase the number of holes, or what is better, we can in this case have a hole in the centre  $1\frac{1}{2}$  inches diameter, through which a bar can be put, and, after ramming up to the vent-rod and venting down to the bottom of the core, cinders must be placed to



the depth of 3 or 4 inches, taking care that they do not come to the outside. After ramming the remainder, vent down to the cinders. It will be readily seen that by this method every part of the core is reached by the vent-wire, and consequently the gas will freely escape through the one large hole in the middle, as *A*, Fig. 106.

Another advantage in limiting the number of vent-holes is that the moulder can secure his work more readily and securely. Now, as this core cannot be as easily handled as the smaller one, some provision must be made for lifting it

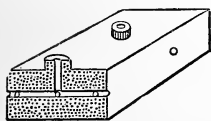


Fig. 107.

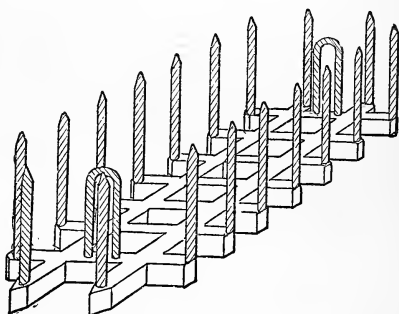


Fig. 108.

into the mould; and, as we have supposed that our core comes through at the ends of the mould, a hole may be made, through which a bar can be passed, or hooks may be rammed up in the core, taking hold of the bottom irons or rods.

Fig. 106 shows section of core where the hook *B* comes, and explains at a glance the different instructions given.

Let us now suppose that our core is 1 inch thick, and we at once see that our room for rods and vents is very limited. We must in this instance be careful to have the vents evenly divided, a little below the half.

The vent-rods and long irons being placed after  $\frac{1}{2}$  inch

of sand is rammed in, the short rods to tie the whole together can be laid across, and the ramming completed. Care must be taken in drawing the vents, or the core will be split. We have, in this case, something to contend with which does not occur in the other cores. The rods cannot exceed  $\frac{1}{4}$  inch diameter, and, being so much weaker, will require more careful handling. We must remember, also, that being so much shallower than the others, the iron in pouring will cover the core quicker, and the vents, being so much smaller, cannot convey the gases away as fast as they should do, especially so when the core is very hard. To overcome this difficulty, it is best to make all this class of cores in fire-sand alone, mixed with molasses-water of medium strength. This leaves the sand very porous, and there will be no difficulty.

But should it occur that the cores we have been speaking of had the iron cast on all six sides, we must then adopt another method to carry off the gas. In the case of a core 6 inches deep, we pass other vents connecting with those running through the length of core, and connect these with the place where we are to take off the vent (which is usually on the top) by as large a hole as possible. Fig. 107 shows the position of vents, which, when all is clear and free, are stopped securely on the outside. In the case of the core with cinders, we simply place upright vents leading from the cinders to wherever the gas is to be taken away.

It may be here stated that where you have only very small holes through which the core must be taken when cleaned out, there must be as few irons used as possible, and no wrought-iron where cast will do.

In some jobs, where the core is not too large, sticks of wood may be used to stiffen the core, and where this can be done with safety, a great amount of trouble is saved in the cleaning.

So far I have spoken of cores made with rods; but it is not always easy to obtain them, and something must be contrived in cast-iron, especially when the cores come larger than the ones I have been describing. My principal object in being so particular in these examples is to show how a makeshift may be made to answer, as the principles laid down will answer for much larger cores than the ones described, and are applicable to cores of different shapes. We will now consider cores of larger dimensions, and show the best methods of making irons for them.

Let the core to be made be 10 feet long, 2 feet wide, and 1 foot 6 inches deep, and when cast surrounded with iron;

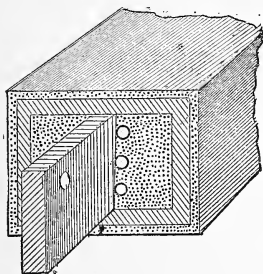


Fig. 109.

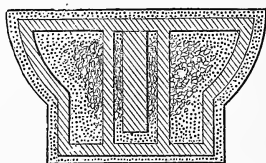


Fig. 110.

in this case we want a sound core with as little core-iron as possible, as it has to be broken up before it can be withdrawn. What we lack in strength of core-iron must be remedied by the number of places we lift the core by. Fig. 108 will explain the kind of iron to be made in this emergency. This iron can be easily stamped or cut out in a soft bed, staples being pushed down the required depth, and the prickers put in to suit the kind of core it is for. Should there be any body of sand to carry below the iron, rods may be cast in to answer.

But should the ends of such a core come through the

mould, a much different arrangement can be made. The core we considered last would require anchors under and over to keep it in place, but this one will allow of a strong beam or girder for main iron, and all we need to do is to tie the sand to it, which is done as shown in Fig. 109, which gives a view of rings around the main iron, with vent-holes on each side, also the hole in bar for lifting core. This plan admits of almost universal application where there is much heavy work made. Fig. 110 shows the method as applied to half-core for water-cylinder 3 feet diameter. Another advantage in this method is that the bar and most of the rings can be saved for future use.

#### PIPE-CORES.

Pipe-cores are often a great trouble, when, if correct methods were adopted for their production, everything would be correct, and all annoyance cease as if by magic.

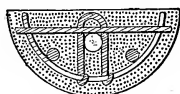


Fig. 111.

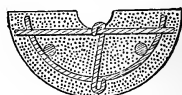


Fig. 112.

The common and sometimes expensive method of using a half-box fails very often—through carelessness or ignorance—to give a good round core, and I have frequently seen one or both halves fall apart in jointing, when, if a little judgment had been exercised by the core-maker, there needed to have been no trouble.

Figs. 111 and 112 show sections of half core with rods bent to suit the curve, these serving the purpose of clamps to keep the sand from spreading away from the main irons, which are shown.

The two methods of jointing are here seen. The plan

of dry jointing is much quicker than the other, if the matter of a little fin is of no consequence.

By adopting this principle of making them, pipe-cores up to 12 inches may be made very readily, and even larger ones at a pinch. I have also shown how hooks may be applied for handling. It is better, in the case of elbows

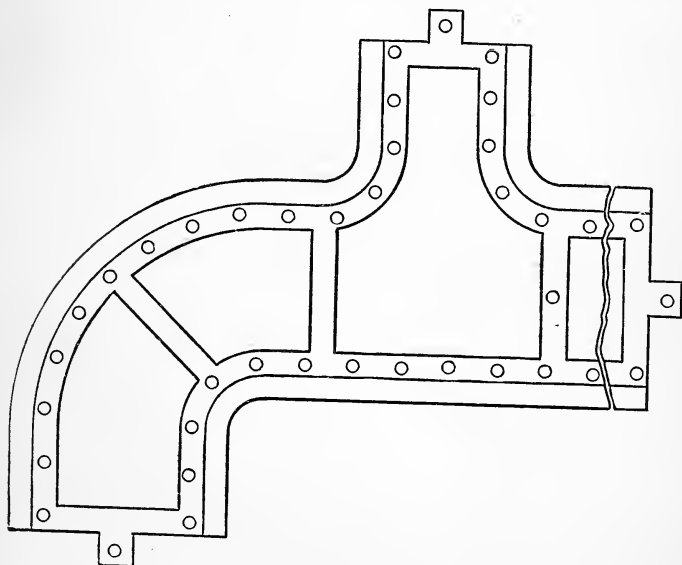


Fig. 113.

and bends, to put two main irons of medium strength, rather than one strong enough, as they can be more easily drawn out. No. 5 core mixture is to be used in these cores.

Larger pipe-cores require different treatment, and as it is seldom that boxes are made for them, I will now show the way to make a 24-inch-diameter core in halves.

We will suppose the pipe to be in the form of Fig. 113.

A template or pattern must be made 1 inch thick, as much wider than the core as will allow the sweep, shown at Fig. 117, to run on the edge with about 1 inch of bearing. Let the template be from 6 inches to 9 inches longer than the casting at all the ends, this extra length being required for bearing or print. From this pattern or template you make—on a level bed—a right and left hand plate from  $\frac{3}{4}$  inch to 1 inch thick, according to strength required.

Another level bed must now be prepared, on which to make the irons. (I have shown in Fig. 12 a section, in perspective, of the kind of core-iron you are to make.) Let your bed be well dug up, sufficiently deep to admit of the pricker pattern being pushed down to the required

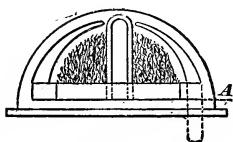


Fig. 114.

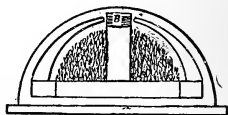


Fig. 115.

depth and direction. After your bed is scraped off, lay your template on, and mark it all around, right and left. From these lines as a guide you must trace out the shape of your iron, setting in from the outside, as far as will leave it clear of the core, about  $1\frac{1}{2}$  inches. After cutting out or stamping down the sand to the right depth and width—which in the case of a 24-inch core would be about 2 inches deep and 3 inches wide—you connect the frame by cross-bars, as shown at Fig. 113, at such parts as will be required for lifting, anchoring, or bolting together, if it should be necessary to do so. Fig. 116 shows staple for lifting, stud for anchor, and hole for bolt. You will require a curved pricker pattern made of iron, tapered as shown, one pattern serving for several sizes of cores. It is well to have the

pricker pattern extend a little beyond the distance it is to be pushed into the sand, the straight end answering for a handle, as shown at *A*, Fig. 114.

To obtain some idea of the direction to push the pricker down, draw elevation of core and iron as shown at Fig. 114, allowing for sand under the core-iron. Place your pricker pattern on the sketch, and mark the depth and angle as seen.

There may be some little difficulty in keeping the pricker at the right angle at first, but a little practice will enable you to bring out your iron a perfect fit every time. I have no hesitation in saying that this makes the best and cheapest iron that can be made, as it can be applied to pipes of all kinds and sizes with absolute safety.

Your plates and irons being cast and cleaned, see that the edge where the sweep will run is smooth; throw on your parting-sand and bed your iron on a thin layer of core-sand. By referring to Figs. 114 and 115 you will see that cinders fill up the core to within a short distance of the prickers; let the cinders be well rammed down, and then ram on the sand. In large cores considerable old or floor sand may be used under the prickers, but it is well to let the core-sand take good hold of them.

Should some of the prickers be too far away from the face of core, a few spike-nails driven in will serve to make up the deficiency.

Should anchors be required in the core, Fig. 115 shows how to put in the stud; let your packing rest on the cross-bar only high enough to admit of a piece of pine wood, say 4 inches square, on which must rest a piece of wrought-iron 3 inches square,  $\frac{3}{8}$  inch thick, the whole to stand  $\frac{1}{2}$  inch below the top of core.

I do this to save the trouble of knocking out the studs, which must be done to save the casting, when anchor, stud, and core-iron are all touching. The plan suggested is

simple: by the time that the thin plate at top has become hot enough to burn the wood, the iron is set, and all danger over. Of course the wood burns away and frees the stud. I have seen many castings break on account of there being no provision made for the shrinkage, or not

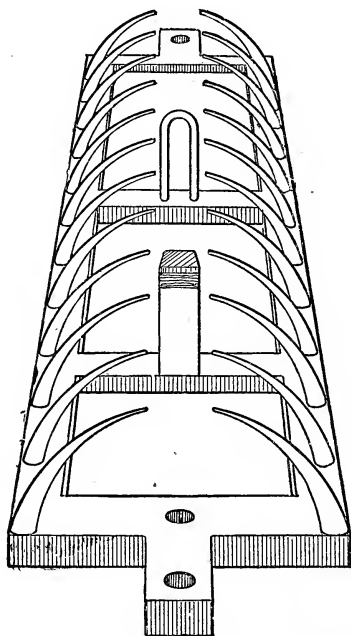


Fig. 116.

being able to get at the stud quick enough. By a careful survey of the figures given, you will see at a glance all that I am desirous of explaining. There will often be places where the sweep will not work, but by making a clean finish up to where it will reach on the plain, the rest will be easily overcome by the careful use of eye and hand.

There are constant demands on the ingenuity of the



moulder or core-maker to save cost of core-box, such as cores where an ordinary sweep, as at Fig. 117, is of no use. For instance, a taper core is needed, for which there is no core-box. Fig. 118 shows a method of making such a core. A half-circle for each end, the diameter required,—secured to straight-edges the length of core,—serves as guide on which to work the strickle.

When proper attention is paid to the making of this kind of core according to instructions given, a very good core can be made in this manner.

It will be seen also that any departure from a plain core can be easily overcome by making the strickle to form the



Fig. 117.

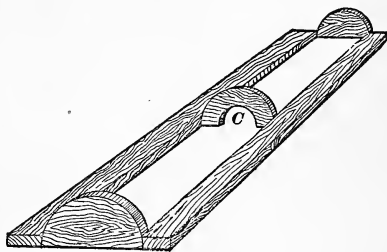


Fig. 118.

shape desired. Where small necks come—as they often do—a piece can be inserted in the frame, over which the strickle can pass as shown at *C*, Fig. 118.

This is done because of the difficulty of dragging the strickle through such a body of sand, leaving the core rough and out of shape.

It must also be observed that in making this core—should the neck be very small, and there be no suitable iron to make it with—that the ordinary straight iron in the length will be of no use, on account of being so far removed from the centre of the core by the intervention of the neck. Figs. 119 and 120 will show how to act in such

a case. It will be well to master the principles involved in this, as well as other problems suggested; for rest assured that, if your work does not turn out correct, it is because you are ignorant of the way it should be done; and just as soon as you begin to ask yourself, "Why is this?" and determine to master first principles in your business, just so soon will your work become attractive, and be a pleasure rather than a burden.

A thorough workman knows from the beginning what the end will be, and leaves nothing to chance.

Sometimes a round core is wanted, some out of the way in size, for which there is no box. Let it be 18 inches by

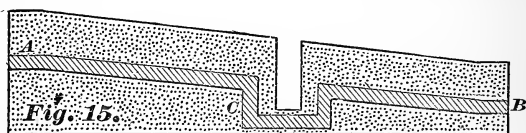


Fig. 119.

15 inches deep. Should there be a pulley pattern, or ring, or coupling-box, the size of core required, place the same on a true plate; set flask or flasks with room to ram sand in hard to the required depth; draw your pattern, and by a little care you may ram up a good core in the mould. After carefully digging away the sand from around the top edge, you may remove flasks, clean off and finish (see Fig. 121). Should there be nothing from which you can make a core this way, and there should be a gig or cross and small spindle handy, run up a course of bricks, and sweep out with mud to size. When the core is rammed, pull the outside off carefully and you have a good core. This plan works well, and saves considerable in pattern-making, where but one is wanted from a job. Should the core be very large, and you have a lifting-plate suitable, the core can be swept at once, and the trouble of ramming saved.

## LOAM-CORES ON BARRELS.

In my travels I have come across foundries where, in searching for a ring or flask in some out-of-the-way place, I have found old core-barrels half buried and rusting away. Asking the reason of their being so far away from the shop and why they were not in use, I have been told that the man who formerly made loam-cores has died, or left for other parts, and, there being no one else in the shop able to make them, they have gone back to the sand-cores.

Now I insist that no man is a thorough core-maker who

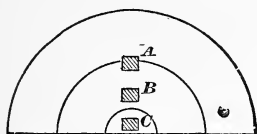


Fig. 120.

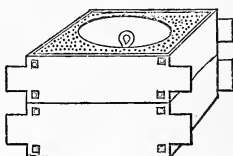


Fig. 121.

cannot make a loam-core, and, as the business is so simple, I will in a few words show what must be done to secure good cores on barrels. In the first place, I have shown, at Fig. 122, a perspective view of the process, from the mounting of the barrel to the finished core. Barrels for small cores can be made of wrought-iron pipe,  $\frac{1}{2}$ -inch holes being drilled irregularly along its length; for, should they be drilled in line, and too close together, they are apt to split the barrel in time; especially is this rule to be observed in barrels made of cast-iron. There must be a groove turned a short distance from each end, to fit bearing in horse, as shown at *A*, Fig. 122, so as to give a smooth, even turn, and insure a round core. When barrels are large, and it comes too expensive to make them of wrought-iron, they can be made of cast-iron, and the vent-holes may be cast in. A

very important feature in the casting of barrels is to have them strong enough; they should not be less than 1 inch thick for a 12-inch core. Care must be taken also to secure an even thickness all round, as they soon become useless from warping if there should be a thick and a thin side. It will be necessary to fit trunnions, Fig. 123, in the ends of

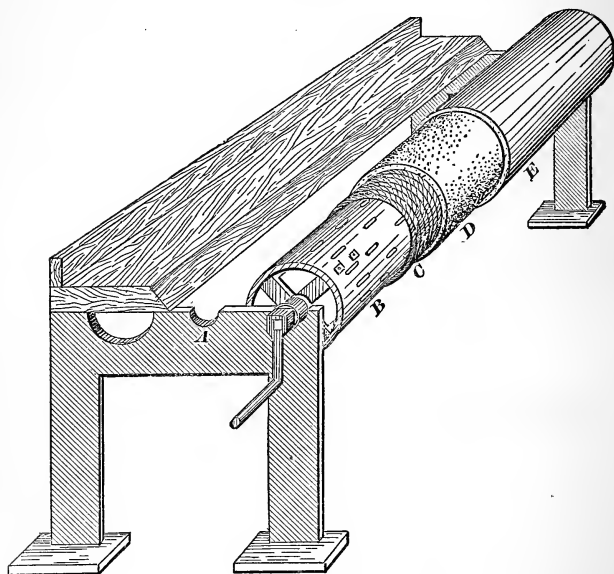


Fig. 122.

large barrels for the purpose of turning and lifting them; let them be as strong as possible, allowing plenty for truing up in the lathe, which must be done after they are secured to the barrel, so as to insure an even body of straw and loam all round the core. The best barrel for the job, all else being satisfactory, is that which will allow from  $\frac{5}{8}$  inch to 1 inch for rope, and same for loam. And in no case, to save a little extra trouble with the smaller barrel,

choose one that will endanger the casting, on account of the ropes being too near the surface of the core; for, should your barrel be a little small, you can overcome that by an extra thickness of loam. But if you are making barrels for special use, you will be governed by the kind of job they are for.

Barrels made for thin pipes, say 6 inches diameter and 9 feet long, must be from 4 inches to  $4\frac{1}{2}$  inches diameter, on which you need only to run a little loose straw or hay. But should your job be a column or pipe 2 inches thick and 15 inches diameter, then you will require your barrel 11 inches on the outside, to allow for about 1 inch for rope, and same for loam.

We will suppose this to be the core you are going to make. After your barrel is ready place it in position, as shown at Fig. 122. You require a strong board or sweep that will rest on the horses, as shown in the figure, the front edge of which must be bevelled to almost a sharp edge. This board, when set to the right distance, will sweep the outside of core.

Where large quantities of the same-sized cores are made, there must be gauges or stops made to set the board, to insure the correct diameter, without the trouble of measuring with the calipers. There are 2 inches to go on the barrel, 1 inch of which will be rope and the rest loam. In making the rope it would be well to consider what it is for. In the first place, it forms a passage for the gas to the holes in the barrel; and, secondly, it enables you to rub on your clay and loam more readily than you could do on the bare iron. But another important feature is that, when the heat has burned it out, it allows of the more easy withdrawal of the barrel.

Now commence to run on the rope, which is done by passing the end over and around the barrel, bringing it under the strand so that your rope will pass over it about

three times, leaving it good and tight. Be careful not to have your rope too close, as, when that is the case, the only resistance which the core offers to the pressure around it is the 1 inch of loam outside, there being no dependence to be placed on the straw, especially, as is often the case, if the core should get a little too much fire. By leaving a little space between, into which the loam can be rubbed, you have then as many studs as you have ropes, and consequently a good sound core. Keep the rope tight as you go, and when one ball is used up slacken the end you hold, as well as the end of the next ball; intertwine them, leaving

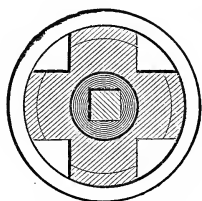


Fig. 123.

some portions to be caught as you pass on to the end. When there, break off your rope and twist the loose straws around a spike-nail, and drive it under and into the rope, taking care to keep it firm and tight.

The next operation is to cover the whole of the rope with clay made from good clay and old sand in about equal quantities, after which press down the rope with a weight held hard down, whilst the barrel is being turned round. This presses in the loose straws, and scrapes off the superfluous clay. After running your fingers along between the ropes, and scraping out the clay, you can rough up your core. As you have about 1 inch to go on, you must divide that and set your board about  $\frac{1}{2}$  inch from the rope.

Temper your loam to the right consistency, and rub it well on, turning slowly towards the sweep as you rub it on. When covered to board as set, remove the board, and lift the core from the horses and run into the oven. As soon as this coat is dry, set back on the horses. Set the sweep so as to bring the core within  $\frac{1}{8}$  inch of size; rub this coat well on, and when your loam is all on up to the board, clean off the sweep and set back  $\frac{1}{16}$  inch, have some finely sifted loam to finish off, and, after finding your size correct and whilst the core is being turned round, pull back the sweep sharply at one end, stop turning when the seam

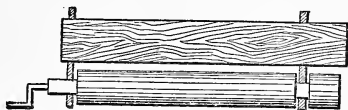


Fig. 124.

caused by the board comes to the top, and your core is then ready for the oven.

By observing the rules laid down it will take but a very short time to become an expert on loam-cores.

In running up barrels with loose hay or straw, a little practice will be necessary. Commence by rubbing a little clay on each end of barrel; pick up as much long straw as you can conveniently handle, and after making fast to one end as before directed, let the straw run from your hands on to the barrel as evenly as you can. When you come to the other end, if your hay or straw be soft and pliable, it can easily be made fast with clay; but should there be any difficulty in this have some short lengths of tie-wire to wrap around. Rub on the clay and press down with a board as it is turned, and proceed as before directed to cover with loam. These cores must be no more than dry,

as if the straw should be burned the core would be loose on the barrel.

So far I have only spoken of the plain cores, but the use of barrels have a much wider range than this. I have known shops where from six to ten men have been constantly working on jobbing pipes from 2 inches to 24 inches, and barrels used to the straight parts of them all; for in the case of elbows short turns can be made, and butted to the end of a loam-core. Fig. 124 shows method of making body-core in loam. The end of barrel stands past the horse from 6 inches to 12 inches, to admit of the core being

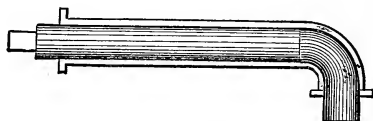


Fig. 125.

swept up to and a little past the end of barrel; this allows for squaring to the body.

When the core is up to size, the top half of space can be filled up with loam, and as soon as the core is sufficiently dry to turn over, the rest can be made good. The end must be well plugged, and levelled off with sand after being squared, to prevent the iron from making its way into the barrel.

Fig. 125 shows cores together in mould. A little more care is needed in the anchoring in this case. Another plan is to fit a loose sleeve into the closed end to turn the core on, knocking it out when the core is finished, and plugging the end; but with delicate cores it does not act so well, as it shakes the core too much in driving out. When, on account of a neck coming into the core, you are obliged to use a very small barrel—and there should not be more than



6 inches to go on—you may run a 1-inch rope and one coat of loam on, and after drying repeat the operation until you get the required diameter, but never put rope on rope when you want a good sound core.

But should you have a core, such as an oil vessel, open only at the small end,—which for a figure we will say is 6 inches diameter, the body 24 inches diameter,—some other plan must be adopted. Procure a barrel not more than 4 inches diameter; insert a plug or sleeve, to turn the core on, into one end. Should the core be about 3 feet 6 inches long, cast three plates,  $\frac{1}{2}$  inch thick, 22 inches diameter, and 5-inch hole in centre, full of small holes to allow the gas to pass through to the barrel, as well as to help in breaking them out of the casting. Cast pricklers 2 inches long on two of the plates, and about 1 inch from the edge cast  $\frac{5}{8}$ -inch holes every 3 or 4 inches. By referring to Fig. 126 the disposition to be made of these plates will be seen.

After keying or wedging plates on the barrel in their proper place, with outside holes opposite each other, run some  $\frac{1}{2}$ -inch rods through the bottom holes as it rests on the horses, and pack large cinders and coke between the plates as firm as you can up to the top, placing in the rods as you come along. Put a small wedge in a few of the top rods to keep them firm, and rub some loam all over without turning the barrel. Fill in the pricklers at the ends with stiff loam, and dry well. When dry put back on the horses again. A little hemp rope run on the small end will answer in this case, as you have only an inch to go on. You must now run a straw or hay rope along the body, so as to leave 1 inch of loam on the outside; rough it up as before directed, and finish. By a careful study of Fig. 126, which is a section of core when cut in halves, it will be at once seen how to make this core. It shows the plates keyed on the barrel, the middle plate having lugs cast on top and bottom to support core in the mould, as well as to

keep it down. The staple is seen on the end plate for lifting purposes.

Should it be required to cast this on end, bolts instead

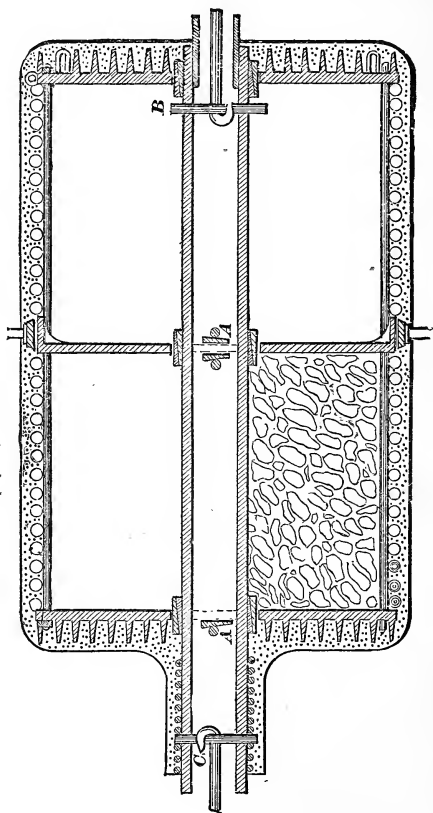


Fig. 126.

of rods may be inserted in three or four places, equally divided, with studs between, and the whole made secure to the barrel by inserting pins in the holes, firmly wedging

between them and the plate, as shown at *A*. At *B* will be seen the way to lift the core on end; this small bar must be inserted before you pack in the cinders. When ready for the mould lift the core on the soft sand, and knock out the plug, being careful to clear away the loam all around it down to the plate; you may hitch on your hook and hoist on end. At *C* is seen the hook for anchoring down.

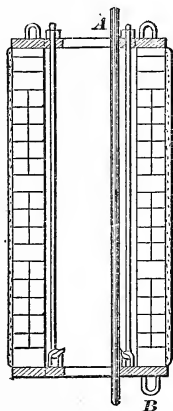


Fig. 127.

After the core is in its place, the barrel must be filled with cinders to within 3 inches of the top, and the hole made good.

Fig. 127 gives elevation of a brick core cut in halves. This plan may be adopted with safety where it would be advantageous. I have built cores in this manner from 18 inches to 36 inches diameter, and as long as 6 feet. Being firmly built and secured, they can be rolled over on the sand and lifted horizontally into the mould by the long bar *A*, or staples may be cast on both top and bottom

plates for that purpose, as at *B*. Of course this plan is not confined to straight cores, as the brickwork can be adapted to any shape required.

In conclusion, I would suggest to the learner in this branch of the moulder's art that he carefully and studiously think over the instructions given, mastering the principles that govern the various operations shown. By so doing he will be enabled to apply them every day in such a manner as will command a recognition only second to the best moulder in the foundry; in fact, I have no hesitation in saying that a first-class core-maker is at all times the most important factor in foundry economy.

## PART III.

### *LOAM-MOULDING.*

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#### LOAM-MOULDING.

IN treating of this very important branch of the iron-founder's art my object is to instruct the moulder in the details of his business, with the view to qualifying him to judge for himself as to the best way of accomplishing the work he may be set to do.

I am persuaded that, to qualify yourself for a loam-moulder, you must master the principles which govern the trade. This once done, every new difficulty will serve to sharpen the intellect, and every day's experience will bring new knowledge, aided by which you will rapidly progress to the highest rank in your profession.

It is to be deplored that so many of our moulders have no fixed principles on which to base their operations. They grope along in the dark, and are constantly wondering how their work will turn out. I know men who are now working on very critical jobs, and are allowed to be first-class workmen, who, if they were asked to explain or give a reason for doing thus and so, would shrink from giving an answer, simply because they are ignorant,—only “that it has been done before.” The principles upon which they work have been laid down by some of the thinking men, and these are mere copyists. I am much

pleased at the efforts which are being made to enlighten such, and hasten to add my little ray to the light which is being directed towards the subject.

Loam work may be divided into three classes: namely, spindle, strickle, and pattern work, some jobs requiring all three systems for their successful working. We will at once commence work with the spindle on a very simple

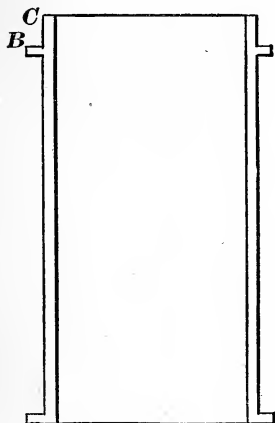


Fig. 128.

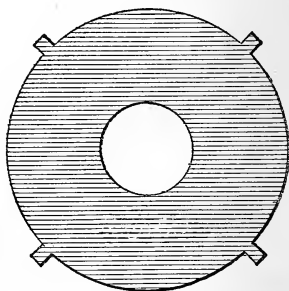


Fig. 129.

job, and, by strict attention to the instructions given, the rudiments of the business will be learned.

Required: A plain cylinder, 3 feet diameter and 6 feet long, with head cast on 6 inch deep to receive the sillage, or dirt, which gathers as it is being cast (see Fig. 128). In the first place make foundation-plate, Fig. 129, to carry the whole mould. The outside diameter of this plate must be 18 inches larger than diameter of flanges, so as to give bearing for cope-ring, which carries the outside of the mould. The diameter of hole in the centre must be about

18 inches smaller than the bore of cylinder, and will then allow of two courses of bricks in the core, should it be required, as it is sometimes when the casting is very deep. Let the plate be 2 inches thick at least, and in all cases be

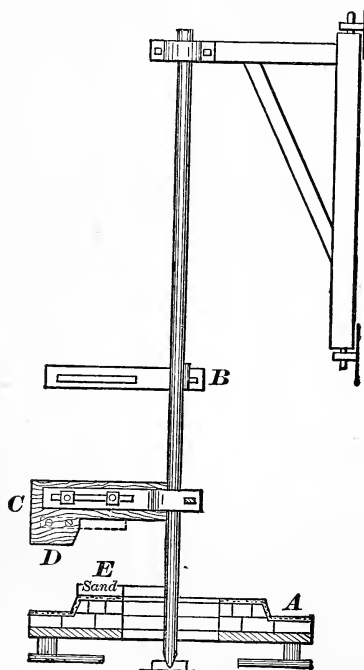


Fig. 130.

sure to have sufficient strength in the bottom plate, because everything must be secured to it. Have the spindle fixed up at some place handy to the oven, if possible, and as well out of the way of the green-sand floor as you can, on account of the rubbish which is constantly being made.

Spindles 10 feet long can be made of 2-inch pipe, with one end welded up, and turned to fit the countersunk hole in the weight it turns in, this weight being bedded level with the floor. Make sure to have your spindle trued up good, as the truer the spindle is, the easier it is to make correct work. Such a spindle carefully used will serve your purpose as well as a solid shaft, and be much easier to handle.

The bracket being fixed to hold the top of spindle perfectly plumb, you are ready to commence operations. Fig. 130 shows bottom plate resting on blocks, and it is very important that a good foundation be made for the blocks to



Fig. 131.



Fig. 132.

rest on; for, should any of the bearings sink down under the load, great trouble ensues. Be sure that the bracket is firmly erected, as no reliance can be placed on work made under a spindle which works loose on the top.

The arm to which the sweep is attached may be made as shown at Fig. 131. It will be seen that a cap is inserted between the spindle and key, to preserve the spindle from dents. Observe that the side of arm to which the sweep is bolted must be on a line with centre of spindle.

At *B*, Fig. 130, slot is shown for key. A good device is shown at Fig. 132 for securing sweeps, being a plate and set-screws, which has this advantage, that the moulder has not to hunt for a wrench every time to loosen or fasten his



sweep. The plate can be made with any number of tapped holes to suit the job.

The first sweep required is the bearing which will take you up to the top of bottom flange shown in Fig. 128. Now, as this is to be not only a bearing, but a guide also, and as you are required to take the impression of this guide in the cope, it must have a taper in its length,

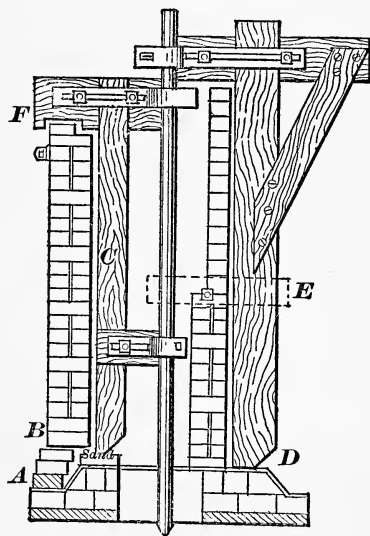


Fig. 133.

as shown at *A*, Fig. 130. By observing sweep as shown at *C*, Fig. 130, it will be seen that it is cut past the taper, exactly the shape of flange. As the first operation is to strike a bearing, as at *A*, you must screw on a thin strip, as shown at broken line, and bring down the sweep to allow about one inch above brick at *D*. Ascertain that your sweep is square with the spindle and correct in diameter. You may then

commence to build as shown at *A*, taking care that your bricks are not closer than half an inch to the sweep. Use mud made from the scrapings of the floor mixed with water, for building with. After the bricks are laid, rub on the loam and sweep off with board; bring up the corner as well as you can; if necessary, hang a charcoal fire over, to dry it sufficient to take the finishing coat or skinning loam, which is the regular loam thinned down with water and sifted.

A quicker way to make the skinning loam is to have the

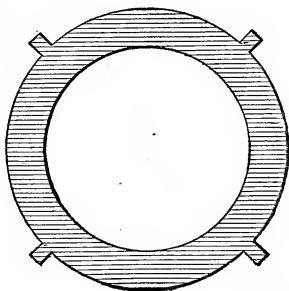


Fig. 134.



Fig. 135.

same proportions of sand without the manure, adding water to bring it to the proper consistency.

You now take off the strip of wood, and, when the mould is hard enough, throw on a little parting-sand, and begin to form the flange in this manner. Have some old sand sifted fine and tempered, ram it on hard with the hands, pulling the sweep along carefully bit by bit, using your trowel to cut the superfluous sand away. By a little care you will succeed in forming the flange as shown at *E*. You must now dampen the sand a little and sleek down well, so as to be  $\frac{1}{16}$  inch clear of the sweep. You can now finish off with thin skinning loam.

Bearing and flange are now formed as seen at *E*, Fig. 130. The thing to be now done is to prepare it so that the impression can be taken clearly. The best way to do this is to go over the surface with coal-oil, and throw on parting-sand whilst it is wet; this makes the best separator for loam work. The reason for striking the flange separate on the bearing is because it is much easier to take the impression this way than it would be to form it by the cope-sweep, as this would necessitate a finger on the bottom of the board, over which the bricks would have to be built, and



Fig. 136.

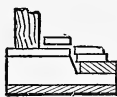


Fig. 137.

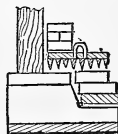


Fig. 138.

fingers or long projections from the board are to be avoided as much as possible. Just think this over a little; it will be profitable.

The outside, or cope, is the next thing to be considered; to carry which a ring must be made as shown at *A*, Fig. 133. Let it be  $\frac{3}{4}$  inch clear of the guide, and wide enough to carry an 8-inch wall, and, what is indispensable, strong enough to carry the cope without springing. A plan of this ring is shown at Fig. 134, where four lugs for lifting are seen, equally divided. Make it even and smooth, as it must rest true on your bearing, without any loam under it.

After bedding down the ring, fasten on your sweep, as shown at Fig. 133. As will be seen, these sweeps are shown as being set against the spindle. This should save any measuring if they are made correct. But sweeps must be used, sometimes, which do not reach the spindle, in which case a gauge-stick must be made, and marked off to the correct diameter—one is shown at Fig. 135.

You now commence to build, bringing your brickwork level with top of flange, where it is necessary to place your bricks endways in, as shown at *B*, Fig. 133. Rub some very wet loam on the under side of bricks as you lay them over the flange, taking care that you have at least  $\frac{1}{2}$  inch of loam between the bricks and flange.

There is a point here it would be well to notice. We suppose the flange in this case to be 3 inches wide, and would stand as shown at Fig. 136. But suppose the flange to be as shown at Fig. 137, 10 inches wide; it will be seen that the brick has no support whatever, and some other

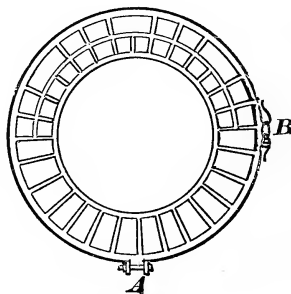


Fig. 139.

mode of working must be adopted. To overcome this difficulty a ring must be made in halves, about  $\frac{3}{4}$  inch thick, with pricklers cast on  $1\frac{1}{4}$  inch long, as seen at Fig. 138. Let it be made 1 inch clear of sweep, and when cleaned off, throw on clay-wash, and fill up level with pricklers with stiff loam; when dry, clean off the dirt and soot, and bed down on the outside brickwork and over the flange, on about  $\frac{1}{2}$  inch of loam. You can then go on with your building as usual. Now follow on with the building, and keep clear of the board  $\frac{1}{2}$  inch; and, when you have built as far as will permit of your reaching the bottom, you must soften

your loam to the proper consistency, and rub it well on the bricks inside, sweeping off as you go.

In building long copes it is well to have a binding course of whole bricks end in about every six courses. Build open and fill in the spaces with fine cinders, keeping the smallest bricks to the inside. Fig. 139 explains what I mean. When the bricks are all laid, and the first coat of loam roughed on, procure a length of strong hoop-iron with ears on, as seen at *A*, Fig. 139. If it should not be convenient to get the ears put on, you may bend the iron, as seen at *B*, and wind softened wire from one hook to the other, and give the strands a few twists with the prong of a file.

This hoop-iron must be placed about the third course from the top, with mud between it and the bricks. This plan answers well to keep the mould stiff on such a cope as this, but when you have larger work, with feet, nozzles, lugs, etc., built in, you must cast a thin binding-ring the width of the brickwork to build in, in place of the hoop-iron.

Before skinning up your cope with the fine loam or slip, go over again with some thin, coarse loam to fill up every crevice and hole, as the fine loam is only intended for a finishing coat, to enable you to make a smoother casting.

In moulds which are too small to admit of a man working in the inside, you must fasten a hand brush to the end of a long staff, and rub or plaster your slip on with it, working the sweep round and round until the surface is smooth all over.

The spindle and sweep can now be lifted out, and the scaffold cleared away. Make good reliable marks at the bottom joint, so that in closing back your cope you will be sure to place it exactly where it was before.

You now want a cross and slings to lift your mould with. A cheap plan to make the one shown at Figs. 140 and 141 is to have a square block the size of the centre, and one

leg. By making it staple down you may cast it open-sand. Amongst the tables given at the end of these articles, one will be found giving the strength of beams, by the use of which a safe estimate of the required depth and thickness may be made. The slings can be made as shown at Fig. 142. You now lift off the cope, setting it up high enough to work under.

The next thing to be done is to build the core. Take away the sand which formed the flange, and set the core sweep. As will be seen at *D*, Fig. 133, this sweep rests on the bottom, and is the full length of core and head, including shrinkage. It will not be as firm as the cope-

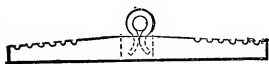


Fig. 140.

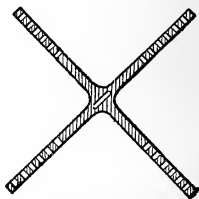


Fig. 141.

board was, on account of being braced at the top only; but you can improve that by using a temporary clip, as shown at *E*, Fig. 133, which is simply two boards, long enough to reach from spindle to sweep, through the centre of which a half-inch bolt is screwed tight. It will be necessary to use the gauge-stick (Fig. 133) in setting this board, this being much more reliable than the rule. Build a few double courses at the bottom, crossing the joints as you go; build up to the clip, and then rough and finish this part of the core. The reason for doing this is that, by finishing the bottom of core whilst the clip is on, the correct diameter will be secured, as well as being perfectly round (something very difficult to accomplish when the sweep

swings loose from the top), and serves as a guide to finish the top of the core by. When the rest of the core is built, and before you rub on the loam, tie it in two or three places with soft wire; this keeps the brickwork firm, and resists the jar caused by running in and out of the oven. The reason for building double bricks at the bottom is because the greatest pressure comes on at the bottom, and, unless extra precautions are taken, the core is pressed in and the hole is much too small, giving considerably more work in the boring than is required.

Your core being skinned up, you must now turn your attention to the portion of cope from top of flange, shown from *B* to *C*, Fig. 128. This part must be formed in the covering-plate, and will rest on both cope and core. To accomplish this you require another plate, the outside diameter of which will be the same as the brickwork

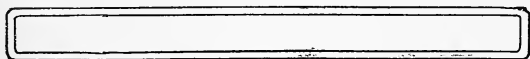


Fig. 142.

at the top flange, whilst the inner diameter will correspond to the inside of brickwork of core. Figs. 143 and 144 show plan and elevation of plate with sweep in position. It will be seen at Fig. 143 that provision is made for running, these holes being cast in so that the gates can be set over the centre of thickness. The pricklers are shown, between which bricks must be built. As this sweep corresponds with the cope-board in its diameter, that would be the guide in laying out the plate, making sure of an inch clear of the sweep. The small pricklers are  $1\frac{1}{2}$  inches long, and can be rammed hard with dry-sand facing, but the bricks between the long pricklers must be roughed up with loam, and then all can be skinned up together. When stiffened sufficiently, the gates can be cut through,

By referring to *F*, in Fig. 133, you will observe how the guide is made to insure the correct position of the covering-plate. By leaving a square edge same distance from centre on the covering-plate, as seen at *F*, Fig. 144, the two parts can be closed as accurately as if you had the inside of the mould to go by. This system of guides will answer in all cases where they can be swept on.

To facilitate the laying out of the gates, a small notch must be cut in the top plate-sweep, as shown at *A*, Fig. 144, so that, when you strike on the skinning loam, there will be a ridge all around, corresponding with the diameter of

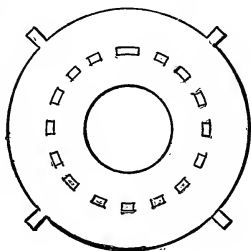


Fig. 143.

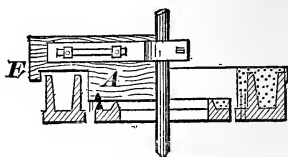


Fig. 144.

core (suppose the casting to be 2 inches thick, this mark would be 2 inches from the outside). It is important that care should be taken in this, so as to avoid striking either cope or core. Should your covering-plate for other work be without any portion of the mould to guide you in this particular, any number of notches may be cut for the purpose of showing the thickness. (See Fig. 145.)

It is important that the gates be well distributed around the cylinder, as the more gates you have the cleaner will be the casting, as they serve to break up and keep in motion the scum which rises as the casting is being poured. A larger hole is shown, which serves as a riser or feeding



head. It is not possible at all times to gate the mould evenly all around; should there be cores or projections in the way, provision must be made for this when the cover-plate is made, and the holes placed where they will miss them.

You must now finish the several parts ready for the oven. First go over the skinned parts of the cope with such tools as are needed to fit the different parts of the mould, taking care not to alter the shape. Should any part have become too hard to finish easily, brush a little water over, to moisten the surface.

A different operation is needed at the bottom flange.

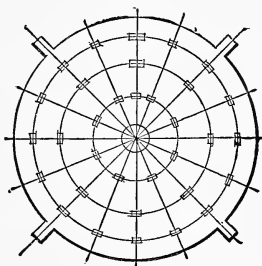


Fig. 145.

After cleaning off the parting-sand which adheres to the loam, and scraping it true, rub up the surface by brushing over some thin skinning loam, and with a rubbing-stick, in the form of a segment of the flange, scrub it evenly all around. When the skin made by the oil is thoroughly broken, and the surface is good and true, brush a little skinning loam all over, and finish with the proper tools, as before. Never use tools unsuitable, as the mould would be all humps and hollows. If you have not the proper tools, it will be better to make the mould as good as possible with the rubbing-sticks, which is very often

done. Pay particular attention to the core; whatever fixing is required, let it be done with the rubbing-stick alone, which in this case would be a piece of soft wood 18 inches  $\times$  3 inches  $\times$  2 inches.

My reasons for so much caution in the use of tools are these: First, there is danger of losing the original design from the unskilful use of them. Second, the least use you make of them, the less danger of scabbing, as repeated smoothing brings the clay to the surface in thin, hard cakes, which usually comes off in thin scabs when the casting is poured.

Blackening the parts is to be next considered.

This is a very important feature in the trade, as, no matter how much pains may have been taken in other ways to secure a handsome casting, it will be all marred by not having the right mixture of blacking for your job, and using it in the right way when it is made. For the job in hand, and all other work of a similar kind, the following mixture will be suitable:

Blackening mixture for general work, from  $\frac{3}{4}$  inch to 4 inches thick.

To 1 of best mineral add  $\frac{1}{2}$  of best heavy charcoal,  $\frac{1}{4}$  of XX silver lead,  $\frac{1}{4}$  of hard Lehigh blacking. Wet with clay-water that will just color the hand, but be sure and not overdo with clay; mix well, and pass through a fine sieve.

In blackening your mould use flat brushes, as they lay the blacking more evenly than the others; cover the surface of the cope to the depth of  $\frac{1}{16}$  inch, and finish carefully with your tools, taking care not to slick any more than is necessary. When the mould is nicely finished, you can paint it all over with a thin mixture of XX silver lead and molasses water, using a flat camel's-hair brush for the purpose.

In blackening the core, brush on evenly  $\frac{1}{16}$  inch thick,

leaving as few brush marks as possible, but do not attempt to slick it. Cores must never be slicked, because, the surface being convex, the skin of the loam is easily loosened with the tools, and a scabbed core is the result. You may slick the flange face at the bottom of the core, and go over with the lead-wash as on the cope, but the body of the core will not need it.

The covering-plate being finished after the manner described, the whole of the parts must be thoroughly dried. When dry, have the pit in which your mould will be closed for casting dug deep enough to leave about 3 feet above the floor.

By a careful examination of Figs. 146 and 147, the method of closing, binding, and ramming will be seen. *A* and *B* are the guides, *C* is the floor-line, *D* the cross on which are hung the slings *E*, which are set under the bottom lugs *F*, and made taut by hoisting on the cross. When all is snug, and every sling is tight, packings *G* must be set under the cross on top plate *H*, and wedged securely between, taking care that the wedges bed close to cross and packing.

I would here observe that wedges should never be put in singly where it can be avoided, and wrought-iron is always preferable to cast, on account of the liability of the latter to snap, thereby endangering the success of your work.

The cross can now be lowered off, leaving the mould firmly bound together. The joints *A*, *B*, *I* must now be stopped in safe by rubbing in thin mud, and all is ready to commence ramming.

At *J*, *K*, *L*, *M* curbs of wrought-iron are shown; they may be from  $\frac{1}{16}$  inch to  $\frac{1}{8}$  inch thick, according to the class of work they are needed for; the lengths may vary from 8 to 10 feet.

It is well to have a few shorter ones, as they are handy for shortening up or lengthening out, as may be required.

Have the holes punched for  $\frac{1}{2}$ -inch bolts, snug fit, about  $1\frac{1}{2}$  inches from the end; about four holes in a 2-foot plate, and three in a 1-foot-6-inch. Use washers in bolting, and be sure that you screw them up close. A few stronger plates may be kept for the bottom course of deep moulds,

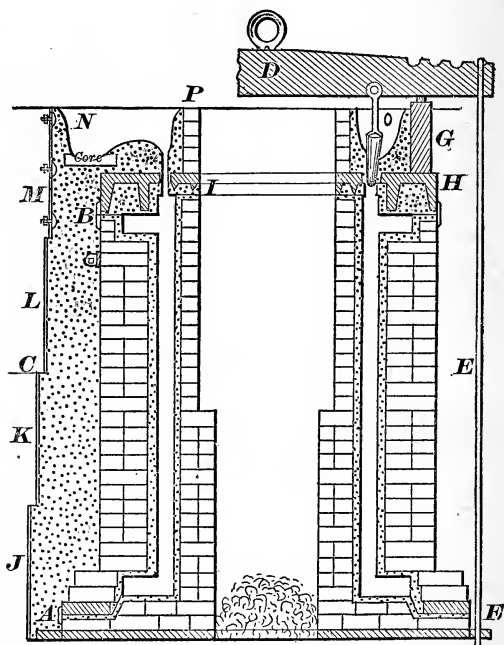


Fig. 146.

with an extra bolt-hole in. In ramming, judgment must be used, so as to save labor. As the greatest pressure comes on the bottom, let the ramming be extra firm at the lower courses, decreasing gradually as you come to the top. The moulder, or some trustworthy man, will superin-

tend this part of the work, using a pin rammer close to the bricks, the rest with flat rammers, keeping 3 inches back. The monotony of the labor will be considerably lessened by all hands keeping time as they ram.

It will be seen in Figs. 146 and 147 how to make the runner. As shown, a few courses of brick are laid up to the inside of top plate, to keep in the sand, or a ring of iron may be set on for that purpose, if there is one handy. As seen at *O*, the riser is much larger than the runners.

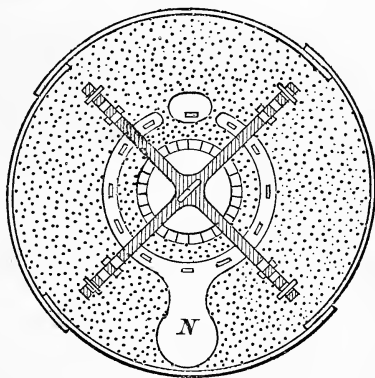


Fig. 147.

Keep the plug in the riser when you pour, and have a man ready with a rod to lift it out as soon as the iron touches it. Be sure to have a few shavings down at the bottom of core, and light them before you commence to pour; this serves to rarefy the cold air in the core, and makes it easier for the gas to escape as you cast. Some moulders say, keep all risers open, and allow the gas to free itself from the mould, thereby insuring a cleaner casting; but I am of the opinion, that whatever good it serves in that direction

is more than neutralized by the consequence of such a method. By keeping all risers closed, the air inside the mould is confined, the expansion of which (as soon as the iron enters) serves a very good purpose; pressing as it does on all its parts, and binding the surface firmly to the brickwork; whilst, on the other hand, if they are left open, the draught and roar act in the opposite way, creating a suction which draws off the surface, and causes scabs and buckles.

I have been describing the method of ramming moulds in curbs, but, as I well know, all shops do not have them, and must in consequence ram in the floor. Where such is the case (and a pit has to be dug where it is the most convenient) make sure that you dig back to good, solid ground, no matter how much extra time it takes. If this should be neglected, it matters little how much you ram around the bricks; there is great danger of giving way, and the casting being lost. So that, considering the risk you run, and the small cost of curbs, it will be readily seen that the safest method will in the end be the cheapest. Some have bricked pits, which are good for special work; but when your job is much smaller than the pit, and you must fill the extra space with sand, to be thrown out again, curbs would save money.

#### HOW TO MAKE A CYLINDER WITH STEAM-WAYS, FOOT AND END CAST ON.

My object in using the plain cylinder as the first lesson was that I might be able to fully explain the rudiments of the trade, as well as to give some idea of the use of materials and tools required; and presuming that you are sufficiently well drilled to make a plain casting in loam, I will now take up something a little more difficult to make. The task before you is chosen on account of the facility it

offers for bringing into play principles which, if firmly grasped, will enable you to understand what you are doing, and qualify you for work still more critical.

Fig. 148 is a sectional view of cylinder cut through at

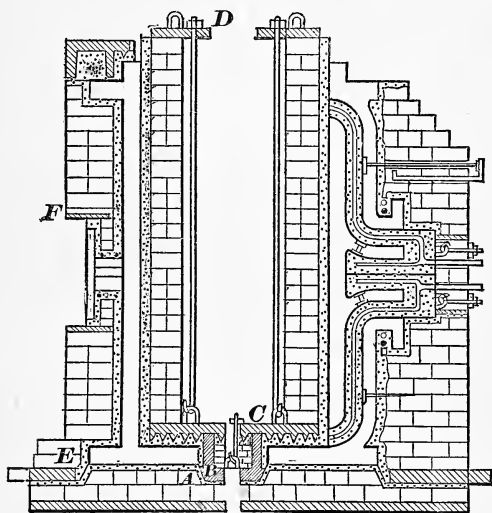
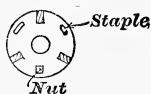


Fig. 148.



Plan at B, Fig. 148.

the middle, showing the mode of making the same. You will observe that the end is cast on, which necessitates another kind of bearing and cope-ring.

Fig. 149 shows cope-ring with extension on front to carry the steam-chest (see that you do not cover one of the bottom lugs when you place it on the seating). Sometimes it is necessary to lift the core of this class of work, in which

case a seating must be struck as shown at *A*, Fig. 148. *B* shows lifting-plate with studs cast on to meet plate for bottom of core. *C* shows covering-plate with hook-bolts for securing *B* to *C*. Fig. 150 is a plan of plate *C*, showing holes for hook-bolts to come through, and staples for securing the whole to lifting-plate. *D*, Fig. 151, shows plan for same. As seen at Fig. 148, the bearing is first struck to *E*, after which the flange is struck and cope built. Sometimes you will have to set the foot and chest

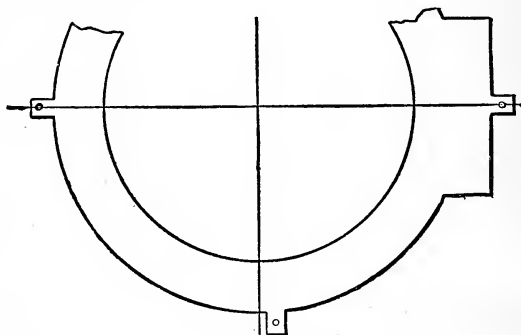


Fig. 149.

to drawing, but, as the pattern-maker is usually on hand at this juncture, you will get along all right by his assistance; but a good plan, and one that insures absolute correctness, is to have a bottom flange made to rest on bearing at *E*, on which a frame can be constructed with four uprights tied by another flange on top; to this frame can be attached anything you may have to cast on the body. After centring the frame and securing it you can (by the use of a guide-stick reaching from flange to flange) build up your mould; after which, when you have taken out the top flange and uprights, you can fasten your sweep to the spindle and strike up the cope.



In building this cope on the foot side you will observe irons, which must reach from side to side to support the bricks above the foot as well as to tie the small space below, and in all confined spaces place a few straws and bring them to the outside, taking care to carry all such vents up to the top when the mould is rammed up. At *F* is seen a plate which is needed to carry the overhanging brickwork. A bearing must be left all round the foot, against which you place a core cake or plate when you close the mould. Don't forget the guide around the

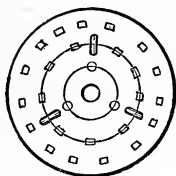


Fig. 150.

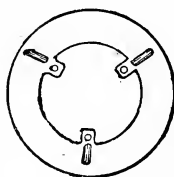


Fig. 151.

top; and cinder the joints of the bricks well. On the opposite side you will observe more need for care in securing across and behind the flanges. Suitable spaces must also be left for bolting back the core s and securing the vents.

The covering-plate differs, as you will see, from the last one; as in this case the body core comes through, making it necessary to cast slots in the inner edge for the runners, as seen at Fig. 152. The inside diameter of top covering-plate, when swept, must be a little slack of the body-core, to insure it slipping on without damaging the mould. After the cope is lifted away, take off the finger which is screwed on the seating-board, spoken of in connection with bottom flange, and shown by dotted lines in Fig. 130, and sweep on the bearing the thickness of the inner

bottom flange with old sand, as before described. It is well that you cover the pricklers of the bottom core-plate *C* with stiff loam, and dry it in the oven before you come to this point, so that it will be ready for use when you want it; care must be taken to keep the pricklers clear of the places which must meet the studs in plate *B*. In making the small plate *B*, have your studs long enough to reach the face of core-plate *C*, allowing  $1\frac{1}{2}$  inches for pricklers and  $\frac{1}{2}$  inch for loam. You now oil the small seating and

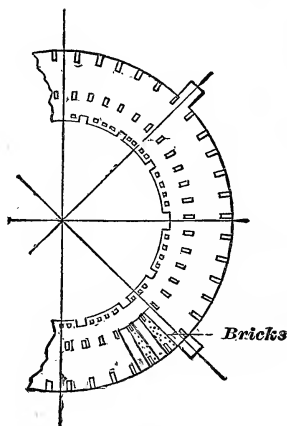


Fig. 152.

set in plate *B*, bed it down solid with no loam under; brick up firmly, bedding the bricks well down level with the top of flange, clean off the core-plate *C*, turn it over, and see that it rests fair on the studs; after satisfying yourself on this point, and observing the thickness of loam required under the plate,—which, as stated before, must not exceed  $\frac{1}{2}$  inch,—rub a little soft loam on the plate *C*, and bed down on a bed of soft loam, making sure that you touch iron and iron on the studs. You must now put on your nuts, and screw them firmly together.

Another plan is to cast nuts in plate *B* instead of staples, and threading both ends of the bolt. You now set the core-sweep and run up the core as shown in Fig. 148. The top plate, *D*, is bedded on and screwed down after the core is swept. By this method you are at liberty to close your mould either by lowering cope over core or lowering body-core in last, which is to be preferred in some instances.

Should it not be required to lift the core out, a method is shown at Fig. 153. As will be seen, the bearing for core comes level with the top of thickness at *A*, by building studs up from bottom plate level with bearing, and casting studs on core-plate (to meet them) as much lower than the pricklers as there will be thickness of loam. In

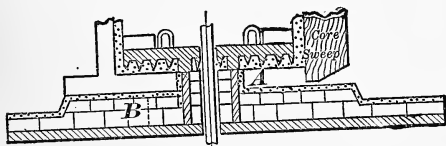


Fig. 153.

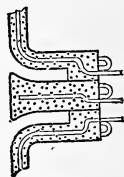


Fig. 154.

this case you may build as much of the bearing as you need for building the cope, as shown by dotted line at *B*. When the cope is lifted away you can build the remainder of the bearing, finish, and blacken. The bottom core-plate in this instance you may either ram up with dry-sand facing, or sweep it with loam level with the studs; after this is dry, finish and blacken, and, when turned over, rest it in its place, stud over stud. This may be bolted down through the centre when the spindle is withdrawn. You can now fill up the flange space with waste, and build the core.

In large cores, where bearing sufficient can be had to support the core with safety, the studs can be omitted; but be very sure before you venture on a core of this kind without them.

It will be observed that this body core comes through the top plate; consequently it must be secured under the cross before casting, in the same manner as directed for cope. Fig. 148 shows the whole set of cores divided at the centre of the exhaust; this is a good plan when the whole set would be too bulky. After the chaplet is set to the correct thickness the bottom half can be placed in and bolted back, after which the top half can be set to its place very readily, and secured in the same manner. Where cores can be thus made, it is far the best and safest; but when (as is often the case) you must have all the cores separate, be sure and have your prints a good length, retaining the thickness between the port and exhaust on the port core; by so doing you will add strength to the port core, and make it safer to handle. Fig. 154 explains what I mean.

For cores which are made separately, have the irons bent to shape, and cast them into cast-iron prints, that will enter the core-box slack; the vent-holes must be cast in, also the staple for bolting back. Be sure in all cases to arrange your brickwork so as to be able to get at your joints and vents handily; and use pipes for leading away the vent wherever you can, as it is the safest.

## MOULDING IN LOAM, FROM A COMPLETE PATTERN.

It is safe to say that if good loam-moulders were as numerous as good green-sand moulders, failures would be less frequent; and also that castings of a higher type of finish would adorn our engine-rooms and factories, as well as public edifices. There is undoubtedly a limit to the practicability of moulding in green sand owing to the instability of the materials used, as well as to the inadequacy of such materials to resist the enormous pressures at work in moulds of considerable magnitude; and, consequently, we look in vain for a reproduction, in the casting, of the even surfaces and symmetrical curves of the pattern; for, from the above-stated causes, all evidence of previous design in the pattern is often entirely obliterated. In addition to this may be mentioned the extra labor which such imperfect work entails on the machinist at the parts which have been prepared for external fittings; also bored surfaces, which suffer on account of the accumulations of dirt and scum, which always form in greater abundance in green-sand moulds than is the case in either dry sand or loam. Examined from this standpoint, it becomes a question whether, in a large majority of cases, the loam casting is not the cheapest, exclusive of the fact of its superiority of finish over the one made in green sand.

Critically speaking, we consider the limit of green-sand moulding to be reached when the moulder fails to accurately duplicate the pattern he moulds from. Just how far this limit is exceeded, from mercenary and other motives, may be discovered by a careful survey of our public buildings, where a considerable percentage of cast-iron has entered

into their construction. To one acquainted with the tricks of the trade, it is easy to find lifter and tool-marks in abundance; places where scabs and swells have been imperfectly removed with the chisel can be readily traced; mouldings and figures imperfectly finished; in fact, botch jobs in most cases, for the simple reason that the founder had attempted to accomplish on a soft, yielding surface of green sand that which only a hard, unyielding surface of loam would have accomplished.

Massive castings, which, if made in green sand, would be full of complications and intricate to mould, and, very often, for the want of ability, unsafe, become in many instances comparatively simple jobs, and easy of manipulation if made in loam, requiring less intelligence, as a rule, to make both a safe mould and a creditable casting.

To meet these emergencies, dry sand is sometimes resorted to; but this method also has its limits, either because the several parts needed for the construction of the mould cause undue expense, or the casting, if too ponderous, would require flasks too large for safe handling. To obviate this latter difficulty, recourse is frequently had to bedding in the floor, using dry sand materials for its construction, and drying the mould where it is made with improvised ovens or fire-pans; but as this is only a makeshift, and not unfrequently a poor one, we shall not dwell upon it.

I am willing to admit that very many of the heavy castings required for mill and forge works, building purposes, and all such as call for strength only, may with propriety be made in green sand; but when along with strength beauty must be combined, then look about for the best method to meet the dual demand, and, when all the pros and cons have been gone over, I conjecture that a loam mould will be decided upon as the safest and best for the job.

To most moulders the idea of making a piece in loam when the entire pattern is supplied seems ridiculous; but a little consideration of the superior advantages offered by this method will soon dispel this illusion. Again, how often we see castings made on end in loam, at great risk and much additional cost to the founder, simply because, perhaps, one tenth of the outside mould can be swept by the spindle; when, if a few lags had been attached to the patterns (which must be made in any case), an entire

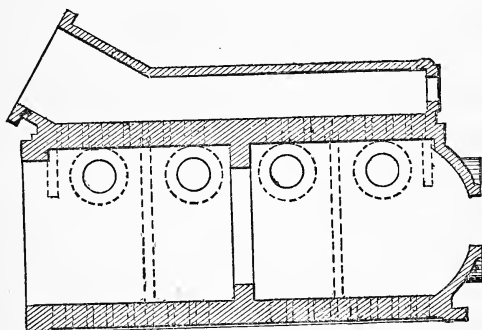


Fig. 155.

pattern would be obtained from which to mould on its flat in such position as would best meet the several requirements of the job.

Many founders object to loam work because of their limited oven space, forgetting that increased facility in that particular would enhance their ability to accomplish larger and better work, and thus secure to themselves a more extended patronage. Self-interest ought to suggest the propriety of being able to make the finest castings, and, having once secured that reputation, there need be no fear for their success. Another objection is that too

much floor-space is required for its production; this objection can, I think, be easily disposed of, as in most cases jobs which, if made in green sand, would cripple the shop for days or perhaps weeks, might be built in loam somewhere aside and convenient to crane and oven, floor-space only being required to pit and cast the mould.

No good green-sand moulder need shrink from the task of moulding in loam; for, rest assured, the difficulties are only apparent. It is not by any means hard to make excellent loam-moulders out of such as are well skilled in green sand, simply because they have become accustomed to construct moulds out of material far more yielding and flexible than that with which the loam-moulder works. There is a decided difference when the opposite task is attempted: the loam-moulder soon discovers the lack of rigidity in the sand compared with the dried loam he has been accustomed to, and invariably retires in disgust.

I will now endeavor to point out the main features in the construction of a first-class loam mould. First, decide at what parts of the pattern the several divisions must be made in order to an easy separation of the walls, due attention at the same time being paid to the closing together of both outside walls and internal cores. Choose the best method of pouring, and arrange for gates in the brickwork or plates, or both if needed. Calculate your ability to transport the parts of the mould, and build accordingly.

In making plates for carrying the several parts, observe the very important rule of having them *strong enough*, and arrange lugs and lifting staples in such order as will secure an even distribution of the weight. When practicable, have all core-irons of sufficient strength to resist upward pressure when secured at the ends. This, of course, necessitates the casting of lugs on all plates at such places as will best meet this requirement. Study to avoid as much as possible the use of studs exposed naked to the iron, always preferring



to make a safe job by some other method, even at the expense of a little extra time; by the exercise of a little ingenuity in this direction serious flaws in the casting may often be prevented.

The accompanying drawings and views represent the water end of a high-duty pumping-engine, such as are made by the firm of Henry R. Worthington. Fig. 155 is a sectional view, and Figs. 156 and 157 are end elevations.

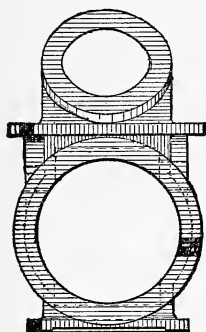


Fig. 156.

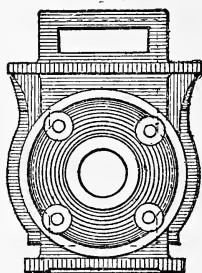


Fig. 157.

The casting weighs from 8 to 10 tons, according to thickness. Castings of this class call for a high degree of finish, inas-much as they are exposed to view, whilst the steam-cylinders are usually covered with ornamental lagging.

A careful study of Fig. 158 will be all that is needed to fully understand the mode of procedure in the early stages of this job. The entire pattern is seen to rest on a bed of loam spread evenly over a course of bricks (previously laid), immediately underneath it. This course of bricks is set back from the edge of the pattern to allow loam sufficient with which to form the joint *A* along the bottom flange. Flange *B* and suction-chamber *C* are detachable from the body, as are all ribs, brackets, hubs, etc.

The arrangement is to build the bottom half of both ends as permanent structures on the foundation-plate, as seen at *D*, Fig. 158, and *A*, Fig. 159, where in both cases only a

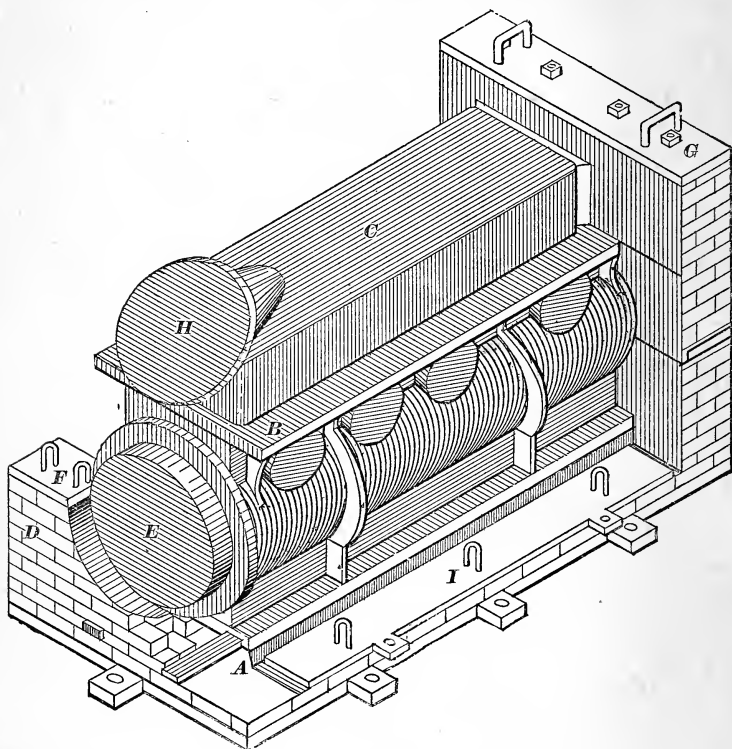


Fig. 158.

portion is shown as built. The separation is made central with the prints *E*, Fig. 158, and *B*, Fig. 159, the building being continued on the lifting-plates *F* and *C*, as shown in the respective figures. Hook bolts, set in the staples shown, serve to bind these walls firmly to the top plates after the manner seen at *G*, Fig. 158, and *D*, Fig. 159.

A careful examination of the view of pattern will show why the plate *D*, Fig. 159, is set below the top. Provision in this case must be made for a joint round the face of branch *H*; therefore the plate *D* must be set below the

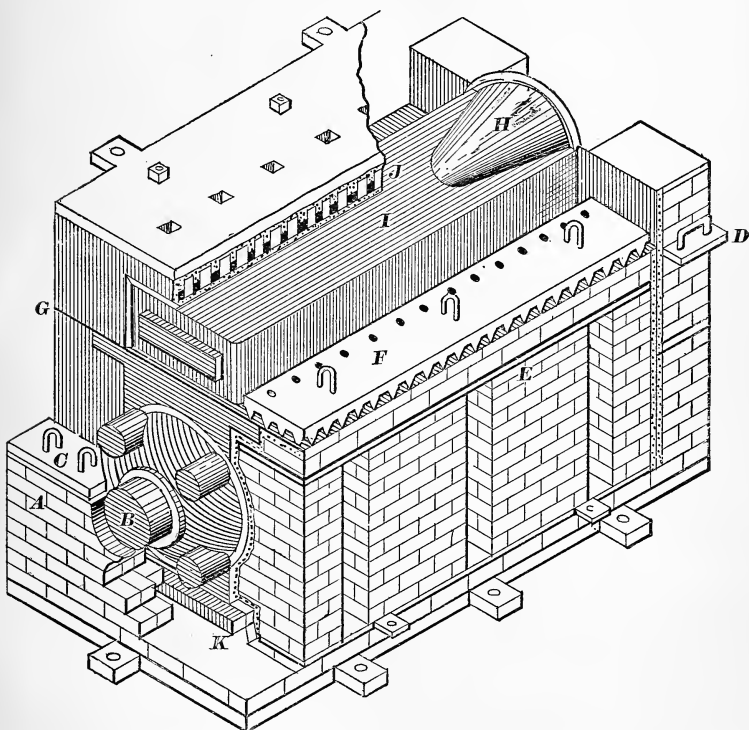


Fig. 159.

flange; and the brickwork continued above in such form as will permit of easy access to the branch when the mould is closed. The method for lifting these ends is clearly shown, and it will be noticed that Fig. 159 is a reversed view of Fig. 158, which allows a full representation of each end in preparation, as well as completed.

Observe that, as the ends are built, the joint against which the sides abut must be formed, strict attention being paid to the necessary taper for easy separation. The sides are shown as built up to the flange in Fig. 159, the method of carrying them being in all respects similar to that shown for the ends. Plate *I*, Fig. 159, rests on a loam bottom against the lower joint *A*; bolts at the staples shown connect with plate *E*, Fig. 159, in which plate-handles are cast for lifting, as seen at *A*, Fig. 160. This figure shows the whole arrangement in section.

As seen at *G*, Fig. 159, and *B*, Fig. 160, another joint is here formed, and the building continued up to the top of suction-chamber *I*, Fig. 159, and *C*, Fig. 160. Plates such as shown at *F*, Fig. 159, serve to carry this brickwork, and are secured, as before explained, by bolts to the top plate, as shown at Figs. 159 and 160. In order to a quick separation of the parts when all is built, have the plates *F*, Fig. 159, covered with loam, level with the pricklers, and dried; the dry loam will absorb enough moisture from the soft loam upon which it is bedded to admit of almost immediate separation. To form the mould over the suction-chamber, lay thin bars across from pier to pier against each course of brick as they are being laid (on soft loam), as seen at *J*, Fig. 159, and *D*, Fig. 160. The top plate at *J*, Fig. 159, is cut midway to expose this method in section, whilst at Fig. 160 the bar is seen resting on the piers.

Enough of detail is shown in these illustrations to give a clear understanding of the whole process of moulding such a casting in loam, and renders any further explanation superfluous. As before stated, all the parts being detachable, such as would interfere with an easy separation of the mould are, of course, to be loosened and allowed to come away with the cheeks.

After marking all the joints, the ends are lifted away; then the top separates at *B*, Fig. 160; after which flange *B*,

Fig. 158, is lifted out, the sides taken away, and the pattern withdrawn. The portion of flange which extends past the end at *K*, Fig. 159, is made loose, built in the end, and drawn out after the pattern has been lifted out.

The lugs shown on the ends of the foundation-plate can be utilized for bolting down the body core, and should it be thought necessary to hold down the middle, have holes in the core-iron to correspond with other holes in the

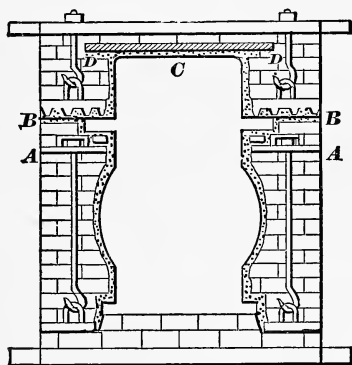


Fig. 160.

foundation-plate directly in line with the centre of one or more of the valve-cores, through which a bolt or bolts can be passed and thus secured.

These instructions are given, not only to show how to make this particular casting, but also to lead the minds of the uninitiated in the direction for grasping the underlying principles which govern the art of loam-moulding, which, if rightly understood, as exhibited in this example, their application to other classes of work becomes easy; for, with very slight modifications of the methods herein displayed, almost every emergency may be successfully met.

## TO MOULD KETTLES AND PANS IN LOAM, WITH FULL INSTRUCTIONS FOR CASTING BOTTOM UP OR BOTTOM DOWN.

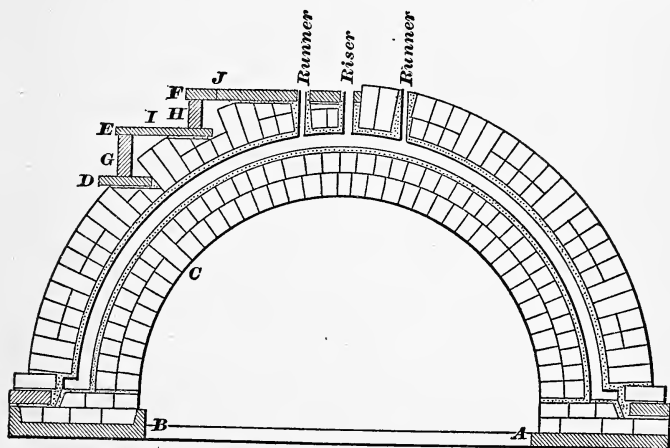
FIG. 161 is a sectional elevation of an 8-foot kettle,  $1\frac{3}{4}$  inches thick, showing the cope closed over core.

In commencing a job like this, let particular attention be paid to the selection of a foundation-plate, making sure that it is strong enough to lift the core without springing. If the plate is plain, as shown at *A*, it should be at least 3 inches thick; but should you have to make one, let it be after the design shown at *B*, and 2 inches thick. The sweep first used forms the core, strikes the bottom of flange, also the seating or guide, and bearing for cope-ring. Build the core with open, coarse mud, keeping the bricks well apart to allow the air to pass freely from the surface. Use half-bricks on the upper course, crossing the joints all along, and putting in a tie-course here and there, as shown at *C*. After the bricks are all laid, clean them off well, and scrape down into the joints. This will help to hold the loam firmly to the bricks. Use your loam soft, rubbing it well on the bricks, and sweeping off as you go around. For the finishing or skimming coat it is best to use the same loam, sifted fine. Your loam being hard enough, take off the thickness, strip, and strike on the thickness, which is done thus: Have some old sand, at the regular green-sand temper, sifted fine; start at the bottom, ramming it on hard with your hand, using the sweep carefully so as not to drag down the sand. After you have struck on the thickness of sand, dampen a little and slick all over, leaving it clear of the sweep about  $\frac{1}{16}$  inch, taking care to trim the corner of flange by pressing it down all around

with your trowel, so as to insure a sharp edge when you skin up.

It is well to make sure of enough skinning loam before you commence, as there is no time to be mixing more (should you be short) after you have once commenced, on account of the old sand absorbing the water so quick and leaving the surface hard; it must therefore be finished at the first pass round, if possible.

When the thickness is hard enough to work on, oil all



**Fig. 161.**

over and throw on parting sand. You now set on the coping, and commence to build the cope, as shown. It will be observed that two ways of building the cope are shown,—one with building-rings, and the other all brick. By placing rings as shown at *D*, *E*, and *F*, and packing between them, as seen at *G* and *H*, you can bind down the mould as soon as it is closed, packing under the cross at *I* and *J*. This I consider the best and safest plan.

But you can build your mould, as shown, without rings,

in which case more care is required in the ramming. When you have rammed the mould as high as shown at *D*, a plate must be bedded on the sand, taking care that it is good and solid underneath. Packing must be placed on this plate in suitable places for wedging under the cross. After ramming a little above the top, another plate must be bedded down clear of the runners, and both firmly bound down with the cross or binders. The gates and riser are shown. The riser being on the top, a sufficient number of  $\frac{3}{4}$ -inch runners, to run the mould full at a lively rate, must be arranged around it, forming a circle about 30 inches diameter.

Do not keep the riser open when you cast, but after making your basin for the flow-off, fill it with soft straw or hay, and place over the hay a dry brick or two, or a piece of core to keep it down. This answers a good purpose, inasmuch as it does not prevent the gas from escaping from the mould; but it does prevent that rush of expanded air which, when the riser is left open, so often damages the crown of the kettle.

Another important matter is to carry off the gas from underneath a hollow mould. I have tried many ways, but prefer the one of making a gutter or trench from the centre of the pit to the outside, in two places, opposite each other if possible. Let the gutter run on a gentle slope to the centre. Should the mould be rammed in the pit, connect these gutters with pipes leading to the top, and just before you cast pour down a little iron so as to reach the centre. This warms and expands the air inside and creates a draught, along which the gas from the core will travel safely.

One great evil of which I would warn moulders is the placing of a great quantity of shavings and wood in the trench and along the bottom.

These taking fire instantly throw such a sudden heat up



to the brickwork as to expand the core and loosen the loam. The consequence is a badly seamed core; or, as I have seen more than once, the casting is lost altogether.

When lugs, eyes, brackets, etc., are to be cast on the outside they may, in many instances be rammed up in a core and the core built in at the proper place; but if the pattern must be bricked in the cope, let the thickness-sweep be nicked at the height required: this leaves a mark all round, and it is then easy to set off to right position, according to drawing.

#### TO MAKE A KETTLE BOTTOM DOWN.

Fig. 162 is a sectional elevation of lead kettle at half its diameter, and shows at a glance the method of building cope and core. The branch core is seen secured by chaplets, with core-cake closed on at the end. The engraving represents a kettle 7 feet 6 inches diameter, 3 feet 9 inches deep. A strong foundation is required for this job, as a great weight is to be carried, the brickwork, as shown, reaching to the outside all the way up. The first sweep used in this case forms the outside, on which (when hard enough) the thickness is swept. Let the brickwork be very open, and use plenty of cinders, leading a vent to the outside from every course. This serves to carry off the steam when drying, as well as to give vent to the gas when cast.

At *A* is seen the bottom plate of core, which, when made, care must be taken in pushing in the prickers, so as to have them the correct depth and position. The staples must be set so as to come directly under the inside lug of covering plate, as shown. This plate, when made, must be turned over, and the prickers packed with cinders to about 3 inches from the point, loam and brick filling the rest. You now dry this, after which it can be cleaned off well, so that no soot clings to it, and if (as stated above) care

has been taken to keep the form of bottom, it will be easily bedded on about  $\frac{3}{4}$  inch of soft loam, which must be spread on the thickness. Lay your bricks as seen until you come to plate *B*. A glance at the engraving will be sufficient to show why the rings *B* and *C* are used. The broken line *E* shows that most of the core to be built hangs past the plate *A*. The inner edge of ring *B*, being supported by plate *A*, carries the brickwork up to ring *C*, which, being supported by ring *B*, carries you past the curve, where the core is almost straight, and there is no need for further support. These rings can be cast thin, and bedded down on soft mud. A plan of top covering plate is shown at Fig. 164, leaving out the four lugs to which centre is attached, and the two swivels which are shown for another purpose, as will be seen further on. The only lugs required in this case are the four inside, for bolting core up to, and the four outside, for lifting.

Two methods are suggested for the top plate. One is to dry a thickness of loam in the pricker, and bed down on soft loam on the joint, and over the brickwork of core at the same time; this is the best plan, as it insures absolute correctness of fit. The other plan is to strike top of core level with outside joint, and after the covering plate is swept with the spindle and dried, it is turned over and laid on. Let the covering plate be cast strong. The one shown has flanges cast on both inner and outer edges, and makes a good plate out of the same quantity of iron which, if cast into a plain plate, would be useless for the job. Before screwing bottom and top together, let studs be set in between, as shown at *F*, and take care they are not too tight before you screw up, as you require to have a good grip on the mould. This core may be finished overhead and set into the oven in the same position, saving the trouble of rolling over.

The method described serves well where the kettle has

branches or lugs cast on, and when the order does not exceed one or two. But should there be an order of plain kettles to make, the cope may remain rammed in the pit after the first one is cast, by securing a centre to the

Fig. 162.

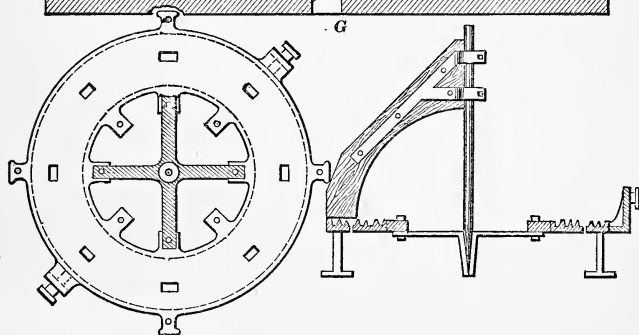
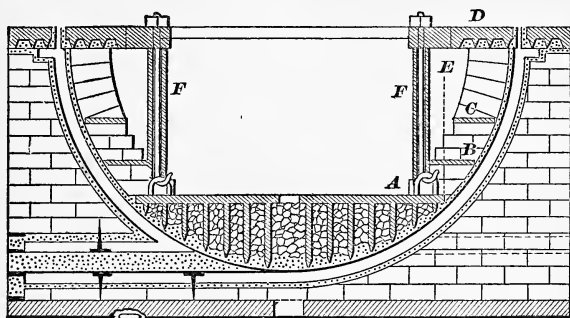


Fig. 164.

Fig. 163.

bottom plate at *G*, sweeping it up where it rests, and drying with a good fire-pan.

The plan for top plate in this case is seen at Fig. 164, and includes, in addition to the lugs for bolting core to, four others, to which a centre must be bolted, as shown, and swivels for turning over by.

Fig. 163 shows top plate with centre attached, set on

stands, with spindle and core-sweep in place. This centre remains a fixture. Let the core be built after the manner shown at Fig. 162, and firmly bolted. If strict attention is paid to the bolts at every cast, and the core lifted from the casting before the shrinkage comes on, you can make a great number of kettles from these moulds; and because with the fixed centres you have nothing to do but clean off well, and sweep off at once, they can be made very rapidly and cheaply. In fact, it is neither more nor less than an extemporized casing.

Good kettles can also be made from a core made in this manner substituting a green-sand bottom for the one in loam. But it would not be well to drop the iron from the top in this case: better to set one or more draw-runners at the bottom, as shown at broken lines, Fig. 162.

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## CASINGS FOR KETTLES AND PANS, AND HOW TO MAKE THEM.

It sometimes occurs that large numbers of kettles are ordered of one size. It becomes important on such occasions to have the best system of making them, in order to make the job pay, as well as to make them rapidly. In the case of such as are plain, and that do not reach a full semicircle in depth, they can be made very easily in casings, which saves both bricking of mould and ramming in the pit, enabling the moulder to make a pan in very short order. Fig. 165a shows section of casings for cope and core, closed and ready for casting.

The mould shown represents a 7-foot 6-inch crystallizing cone 3 feet 5 inches deep. These casings can be swept in loam and cast about 1 inch thick, with holes about every 6 inches all over them. These holes must be  $\frac{3}{4}$  inch and

$\frac{5}{8}$  inch at ends, and must be placed with the small end outwards, so that the loam will wedge fast in them, and prevent their bursting out when the iron is poured in.

An allowance of from  $\frac{3}{4}$  inch to 1 inch must be made for loam on the body and bottom of flange; the bearings and guides will do with less. Observe at *A*, Fig. 168, a projection is cast on cope casing; this serves to hold up the loam when it is turned over, and must be made as deep as possible. At Figs. 166 and 167 are seen the arrangement for spindles and sweep. The socket on the core casing is in-

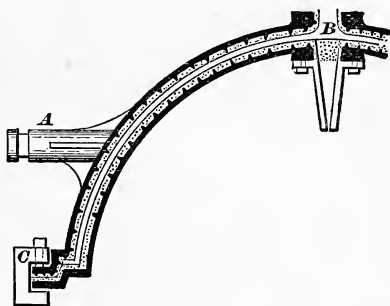


Fig. 165a.

tended to be a fixture, but that on the cope requires to be taken off each cast.

The swivel is also shown at *A*, Figs. 165 and 166, and at Fig. 166 the horse is shown on which the cope is to be turned, and serves as a rest while it is swept up. Let the face of casings be prickered as shown, so as to bind the loam more firmly to them. Lugs may be cast on for lifting purposes. If convenient, have both casings rest on the carriage whilst they are being swept, and have them warm when you commence. After roughing on the first coat let them be dried, and should it be inconvenient to run both moulds into the oven, the cope can be dried by

suspending a large kettle fire in the inside and covering over with sheet-iron; this method will soon dry it. Before putting on the finishing coat have the moulds well cleaned,

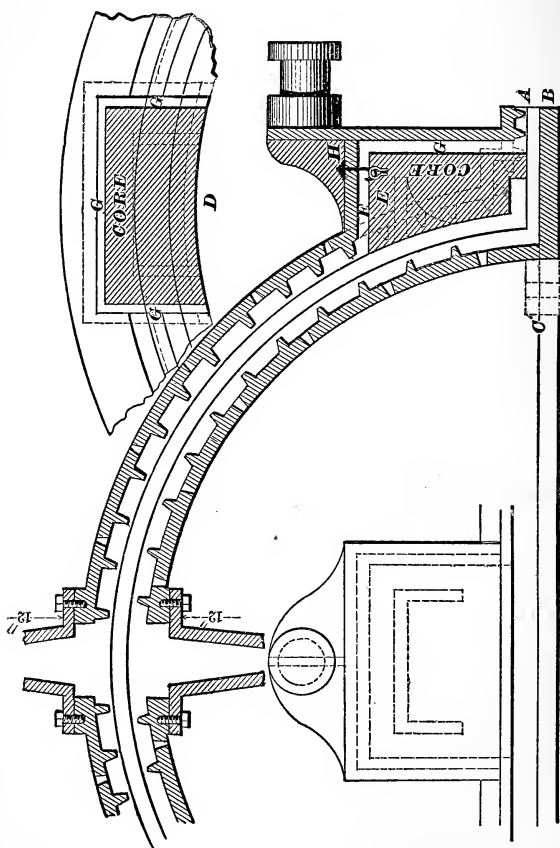


Fig. 165b.

and use your slip thin, and be sure to rub it well in, for should there be any slack places, scabs are sure to ensue. After the sweep and spindle are lifted from the core, a

loam plug can be inserted into the hole at the crown, as seen at *B*, Fig. 165a. Should your spindle for the cope be about from 3 inches to  $3\frac{1}{2}$  inches, the hole left by such spindle would serve as the runner, taking care to cut a large fillet round it; this allows the iron to escape more freely into the mould when the kettle is thin.

At *C*, Fig. 165a, is shown the method of clamping the moulds together to cast. Should you have to cast on the floor, you must set down on packings 10 inches high. Let the top of your runner be not less than 18 inches from the

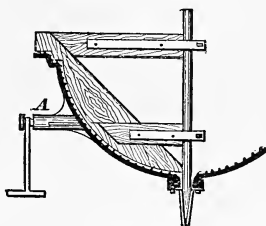


Fig. 166.

crown of the pan, and in casting be sure to keep the runner full from the beginning. It is important that shavings be placed all around underneath the casing, and have them blazing when you begin to pour. As you must lift the casting from the casing as soon as it is safe to do so, on account of danger from shrinkage, it is important that everything should be in readiness for quick work. To that end arrange your runner so that it can be tapped. After clearing around the gate, and the clamps are all off, hitch on to the swivels.

I have shown at Fig. 168 a handy method for lifting the casting. When the bottom of casing is hoisted as high as the bottom of the flange, clear away the loam and insert as many of the dogs (shown at *B*, Fig. 168) as will lift away the casting without warping it; screw these firmly to the

casing, and the casting will be lifted as you hoist off. If you should not have a suitable iron truck to load on to at once, the casting had better be lowered on weights levelled for the purpose. As an extra precaution, when the pan is very thin and deep, the form of the inside casing may be made as shown by broken lines at *C*, Fig. 168. But when the casting is shallow, and a reasonable amount of speed be made, there is very little danger from shrinkage. Sometimes the outer casing can be rigged so as to make a smaller pan than it was made for, by securing a ring around the inner edge at *A*, Fig. 168, to carry the necessary

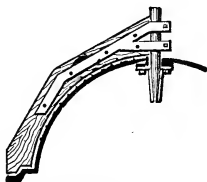


Fig. 167.

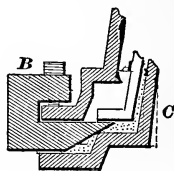


Fig. 168.

brickwork. When such can be done a great saving is effected, as all that is required is to clamp down firmly to the plate which carries the core, and in all other respects proceed as directed when core casing is used.

Fig. 165b shows how to make a casing when lugs and brackets are to be cast on. In this case I have done away with the guide-bearing, simply sweeping the outer guide, as seen at *A*. The bottom plate for core may be cast separate from internal casing (in open sand) and bolted together as shown by broken lines at *C*. A little different arrangement of swivels is here shown, it being just as well to attach them to two of the brackets. Core forming the bracket is shown in plan at *D*, and in elevation at *E*. Bearings for the cores can be swept with core sand in each pocket to the correct height at *F*. It will be seen that space is



allowed all round the core at *G*, into which (when the cores are set) sand can be rammed hard ; but should this be insufficient to hold up the core, hook bolts may be used, as shown at *H*, the holes being cast or drilled into the casing for the purpose. I have no hesitation in saying the very best work can be done in casings, and pans from  $\frac{1}{2}$  inch to 6 inches thick can be made without a flaw, when proper care is taken.

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## MOULDING CONDENSERS, TANKS, HOT-WELLS, CISTERNS, ETC., IN LOAM.

THE castings enumerated above vary considerably as to size, shape, and thickness, some being square, others oblong, whilst again others are made in the form of an L, etc. Such work is required principally by firms whose business it is to build marine and stationary engines, and as such firms invariably have foundries of their own, it seldom finds its way into the jobbing shops. Not unfrequently the latter firms, should they receive an order for anything in this line, will sublet it to some engine-shop, believing that such work is too difficult for them to risk their money upon.

There are large numbers of loam-moulders of considerable experience with the spindle and sweep who would hesitate to start on this class of work without some previous instruction. It is in part for their benefit that these directions are offered, although, as will be discovered farther on, they are eminently adapted to the student as well.

By taking a square tank or hot-well, 4 feet 6 inches square, and the same in depth, and showing how to mould it, we shall master the principles which, with slight modifi-

cations, will enable us to make any of the above-mentioned castings.

Fig. 169 illustrates the foundation part of this job, when it is intended to cast the bottom of the casting uppermost in the mould; the frame *B*, from which the cope and core are to be formed, rests upon the prepared seating *C*. This

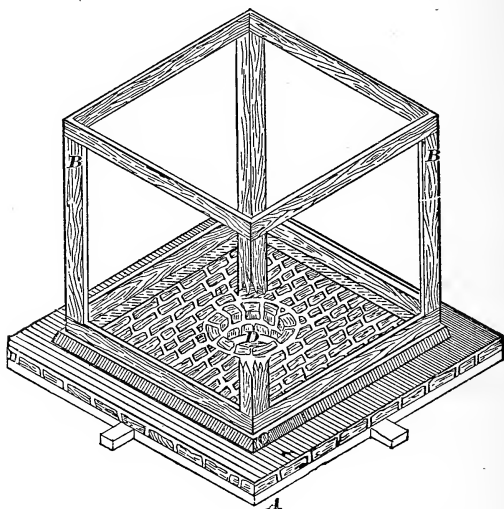


Fig. 169.

frame is all the pattern needed for moulding such a casting as we have in hand.

Fig. 107 is a sectional elevation of the mould when finished and closed together. The foundation plate *A* must not be less than 2 inches thick if it is made plain on both sides; but if a flange is formed all along the outer edge 3 inches deep and  $1\frac{1}{4}$  inches thick, the plate will answer if made  $1\frac{1}{4}$  inches in thickness. The latter is the best foundation-plate in all cases, especially when cross-ribs are added according to the strength required.

It will be seen that this plate is made large enough to allow a 9-inch wall being built on all sides, and in this case a 12-inch hole is left in the centre at *D*. (It will be well to refer to both figures, as the lettering is the same in each.)

It may here be observed that it is not necessary to use a spindle and centre to mould this casting; two straight-

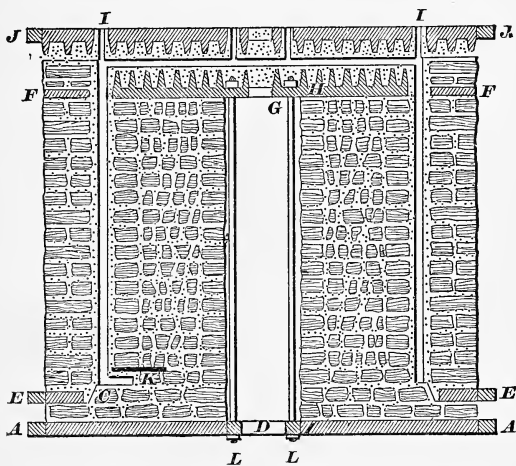


Fig. 170.

edges may be set to the correct height, and the bearings swept off direct with a third one. Should there be a spindle, then a parallel sweep may be used for the purpose; in either case the directions given will serve.

After the foundation-plate has been set down level, begin by setting thereon one course of brick all over, as shown, on which a bed must be swept to form a bearing for the cope-ring *E*. When this has become hard enough, centre the frame and mark off its outline, then build another course of bricks inside the line, allowing for a thickness of loam with which to form a joint or guide, as seen

at *C*, Figs. 169 and 170. The bed swept on this course of bricks forms the bottom of the mould, and it is on this bed that the frame is seen to rest at Fig. 169. When forming this guide, be sure to give the requisite taper for quick clearance.

The best method of separating all such joints is to brush oil over the surface and sprinkle thereon a little parting-sand. When this is done, bed down the cope-ring, as seen at *E*, Fig. 170.

This ring must be strong, with the lugs made to correspond with those on the foundation-plate, as shown at Fig. 171.

Before commencing to build the cope, brush a little oil over the frame, to prevent the loam from adhering to it; and in laying the bricks, observe the rule to keep them half an inch back from the surface of the mould. The strickle for sweeping out the spaces will serve as a guide in building.

As shown at Fig. 170, the brick-work is continued as far as *F*, at which place a binding-ring is set on. This ring serves two purposes: it prevents the mould from splitting when it is being lifted, and also stiffens the wall sufficiently, in this case, to prevent damage from ramming. When the walls are deeper or longer than those under consideration, more of the binders are needed; and it may be found necessary, in some cases, to still further strengthen them by bolting the upper to the lower plates, as seen at *A*, *B*, and *C*, Fig. 172.

The remaining courses of brick over the binding-plate are set so as to leave half an inch for loam, with which to finish the walls true to the top edge of the frame. When this has been done, and the spaces swept off as correctly as possible, the frame must be withdrawn and the cope lifted away.

After replacing the frame, proceed to build the core

after the manner shown at Fig. 170. Form a 9-inch course along the outside and a circle at the centre, corresponding to the hole in the foundation plate, which is 12 inches, and set in halves and pieces of brick between. Leave wide spaces for fine cinders to be packed in; this forms a con-

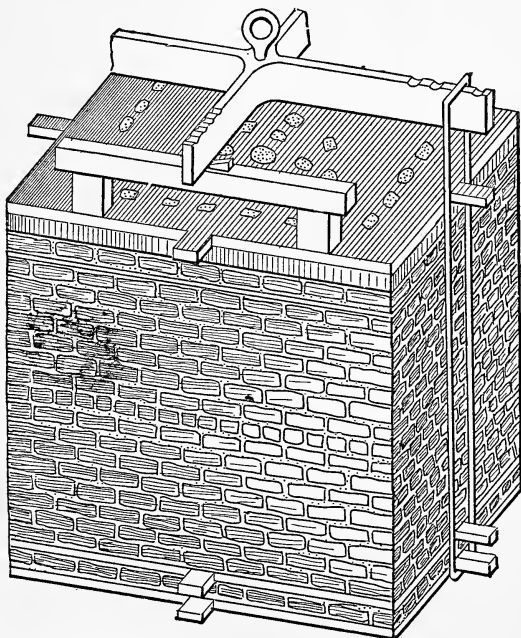


Fig. 171.

tinuous vent from circumference to centre at each course of bricks, all the way up. It is best to bed all the bricks on mud, and (excepting next the casting, use no more than is necessary to give a firm set to the bricks; this, in conjunction with the cinder packing, gives solidity to the core, and enables it to withstand the pressure exerted against

the sides when the mould is poured. Again, these cinders will be found serviceable when you dig out the core immediately after casting, which would require to be done in this case if the tank was under  $\frac{3}{4}$  inch thick. But the one under consideration being one inch in thickness, there is no danger on account of shrinkage, if the instructions are faithfully followed ; especially remembering to allow wide spaces between the bricks endways of the walls of the core.

The 12-inch hole left in the middle of the core will be a great help in drying, if the hole in the centre of crown-plate be left open, which it must be, until the mould is placed in the pit for closing; it can then be filled with brickbats and cinders up to the plate at *G*, and then finished by inserting a dried plug of loam.

The crown-plate *H*, for a job of this kind, would require to be  $\frac{3}{4}$  inch thick, and 1 inch clearance on all sides. The pricklers seen are 3 inches long. Let plenty of holes be cast in the plate to allow the gas from the upper surface to pass freely to the centre of the core. To do this effectively it is best to rest only 6 inches of the outside of the plate on mud or loam; this will serve to bind the core, the rest will do of fine cinders. The connection is then made by filling more cinders amongst the pricklers to the depth of an inch, and if the casting must be run on the crown, as is sometimes advisable, cover with the regular loam mixture, pressing in dry brickbats to absorb the moisture.

In very thin bottoms it is always best to run on top, spreading the gates from the centre, as seen on covering-plate, Fig. 171. In the event of running all the iron down the sides, as at *I*, Fig. 170, the loam for the crown should be made very open and weak, water, in some instances, being preferable to clay-wash for making the loam with; for, should the surface be close and hard, the metal will sometimes refuse to rest on it quietly, and then bubbles ensue. After striking out the top and side spaces as before di-

rected, and after the core has hardened well, take off the frame and finish in the ordinary way.

The covering-plate for this job is shown in section at *J*, Fig. 170; it is also seen in position at the view of closed mould, Fig. 171. Any further explanation of this plate, other than is to be got from a study of the views mentioned, would be superfluous. Suffice it to say, be sure to

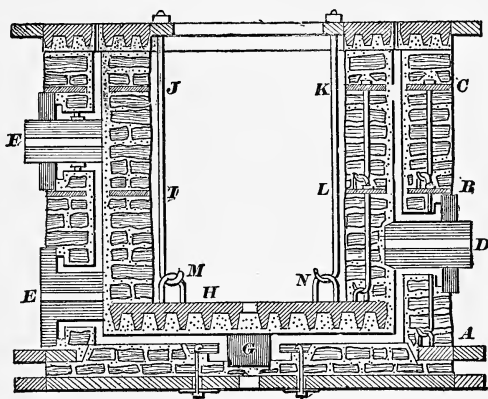


Fig. 172.

have it strong enough—in this instance not less than two inches thick.

To prepare this plate, it may be either swept with the spindle or struck off to straight-edges, dry-sand facing being rammed on it rather than loam, as the latter leaves a hard surface, against which the metal does not always rest kindly, as is the case when the former-mentioned material is used.

Fig. 171 fully explains the closing and securing of this mould; one of the four slings is seen in position, also one set of packings under the cross. When all four sides are packed thus, eight places are caught instead of four. By

adopting this method the plate is prevented from springing. Additional props can be introduced at any other point where it may be considered advisable, either singly or by the combination shown.

To carry off the gas generated in this core when the mould is poured, let a trench be dug, 12 inches wide, from the centre of the bed on which the core is to rest, to the walls of the pit. Have this trench filled with cinders or ashes, and connect with a pipe, which will reach the top of the pit, if the whole pit is to be rammed; but if curbs are used in which to ram the mould, escape for the gas may be provided for by leaving the end of the trench uncovered. There is absolutely no danger of an explosion with a core built as herein directed, and the trench prepared as above.

So far we have only been moulding a plain casting; we will now inquire into the mode of procedure where branches, flanges, brackets, etc., are added.

Sometimes internal flanges are required, as at *K*, Fig. 170. These must be made loose, and set to place when the frame has been set back on the bed to build the core. In the event of such flange not exceeding three inches wide, a course of bricks, laid endways over it, will be all that is needed to carry the wall above; if wider than three inches, lay an iron rod alongside each brick, of a length sufficient to act as a counterbalance to the weight over the flange.

In the case of a plain casting it is unnecessary to bolt down the core, but when flanges are introduced as described, an anchor of some kind is indispensable. For all ordinary cases the method shown at *L* will answer the purpose, but should the flange be required of extraordinary width, the increased pressure at that part would necessitate extra precautions to resist it, otherwise the core will rise and the casting be lost. In such a case the bottom bed must be struck wide enough for the flange, a pattern for which can be dispensed with by simply making a tempor-



ary frame, as high as the thickness of flange, with which to form a bearing for the covering-plate.

This covering-plate must be prepared to set over the flange when finished, and bolted securely to the foundation-plate, through holes cast to correspond with each other in both plates.

When branches, brackets, etc., are to be cast on the tank or hot-well, the patterns of such may be secured to the frame by inserting a cross-bar on which to screw them fast, then build around in the regular way. Fig. 172 shows three branches, *D*, *E*, *F*, drawn for the purpose of explaining as many different methods of setting in the core and covering-cake. In all three it is seen that a guide-bearing for the covering-cake is prepared true to the face of flange;



Fig. 173.

this bearing may be a part of the pattern, or it may be swept by a strickle, kept in position by a centre pin.

At *D* the covering-cake is first set up and made fast; the core is then to be pushed through until the end is firmly fixed into the seating prepared for it in the body core.

At *E* the covering-cake and core are in one piece, whilst at *F* the core is supposed to have been centred by chaplets or studs, and the covering-cake slipped on last. All of these methods will be found equally applicable according to the circumstances which govern the job in hand.

If a branch be required on the bottom of the mould, it will be found easy of accomplishment if the method shown at *G*, Fig. 172, be adopted. It will be seen that the space

betwixt the flange and the body of the casting is blocked out, and a core inserted to form such space. This core may be secured in many ways, but the one shown, bolting to the foundation-plate, is the safest.

When branches come on the top, the method illustrated at Fig. 173 will be found the most simple. Have the hole in

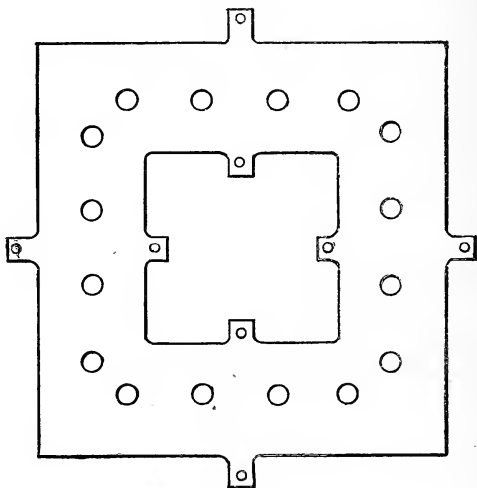


Fig. 174.

the covering-plate made large enough to slip over the flange of the branch easily (this obviates the breaking of the covering-plate), and when this has been swept, finished and dried, let it be turned over and set on the joint of the cope before it (the cope) is lifted off the seating; the pattern for the branch in the mean time having been secured to the frame by means of the cross-bar alluded to above, and propped underneath. A few cranked irons, as seen, will serve to carry the loam and bricks, with which the wide space is filled, over which the building can be continued to

the top. If for any reason it should be required to turn the top plate over again, the brickwork round the branch can be secured to the plate, by using another plate made to rest thereon, with lugs *A* having holes cast in to correspond with staples *B*, cast in the covering-plate, and by this means binding all together with hook bolts.

Before lifting off the covering-plate, let guide-marks be made, to insure the correct closing of the mould.

To make this casting with the bottom down, as seen at Fig. 172, we must make an entire change in the methods of working, as will be observed if the figure is studied carefully.

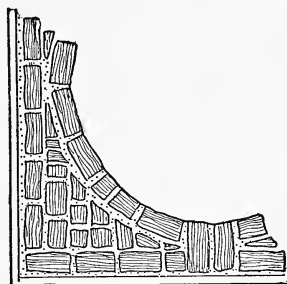


Fig. 175.

In this case, when the cope or outside has been built and lifted away, the bottom of the mould must be swept off and finished, and when this has sufficiently hardened, a bed of sand, equal to the thickness required, must be rammed over it; also, let the bottom-plate *H* be prepared and dried, after which it is turned over and laid central on the thickness. The frame is then replaced for building the core. As seen, this core is not built solid; a 9-inch wall will serve the purpose, if binding-plates are set in, as shown at *I* and *J*. These binders are needed to help resist the pressure which comes against the walls when the mould is cast.

In larger castings it is important that greater strength be imparted to the walls. This may be done by bolting the binders together, as at *K* and *L*; and in the case of very extended surfaces it will be necessary to prop each side to its opposite, by an arrangement of studs or joists, firmly wedged in.

In some jobs it is possible to obviate very much of this bolting and staying, by building an inside course of bricks to a true circle, and filling in the corners with open brick-work and cinders, as shown in plan at Fig. 175.

The lifting-staples, two of which are shown at *M* and *N*, are set to come under the holes cast in the inner lugs of the covering-plate, a plan of which plate is shown at Fig. 174.

The core is to remain resting on the thickness, until the whole mould is finished and dried; the cope is then closed over the core, the covering-plate brought into position, and the core firmly bolted up to it. The whole is then to be lifted off the seating by hitching to the cope-ring, and when the sand thickness has been removed, lowered back in its place.

It will be readily seen that, to make these castings in the manner treated of last, all the plates and rings must be made much stronger than is called for in the former case, because the covering-plate sustains the core, the cope-ring must lift cope, top-plate, and core, and the bottom-plate and cross must resist a pressure equal to four times the amount exerted in the former instance.

## TO MOULD A SCREW-PROPELLER IN LOAM.

THE moulder who has never seen a propeller-wheel made has, no doubt, often asked himself the question, How is it done?

In explaining the method which I believe to be the best, I shall confine myself as strictly as possible to the moulder's share of the work; for it must be understood that the pattern-maker comes in for the lion's share of the credit in making wheels, and any moulder who should be called on to try his 'prentice-hand on this job will do well to remember this, and keep on comfortable terms with him.

I have chosen a three-blade wheel, 10 feet diameter, to make, as it enables me to give a better perspective view of the work as it progresses. Let the foundation-plate *A*, Fig. 176, be 12 feet diameter, resting on firm ground, and begin by striking the bearings *B* and *C*, Fig. 176.

The sweep for striking these bearings will bring the bottom of the hub high enough to allow the blades to be built. As the hub in this case is about 24 inches diameter, a wood pattern is out of the question. Two ways are open to the moulder to form the hub: one is, to work a sweep against the spindle as the blades are being built; the other, to build a dummy pattern on bearing *C*, before commencing the blades. Such a one is shown at *D*, Fig. 176. Now, let a line be drawn all round the outside, as seen at *E*, and divided according to number of blades, which in this case is three. The inclined frame *F* is now set to line *E*, with centre-line *G* at line *H* on bearing *B*.

With the view of helping the beginner in this job, I would here call his attention to Fig. 177, which is a per-

spective view of the blades as they will appear when built. By so doing he will better understand the various instructions he is called upon to follow.

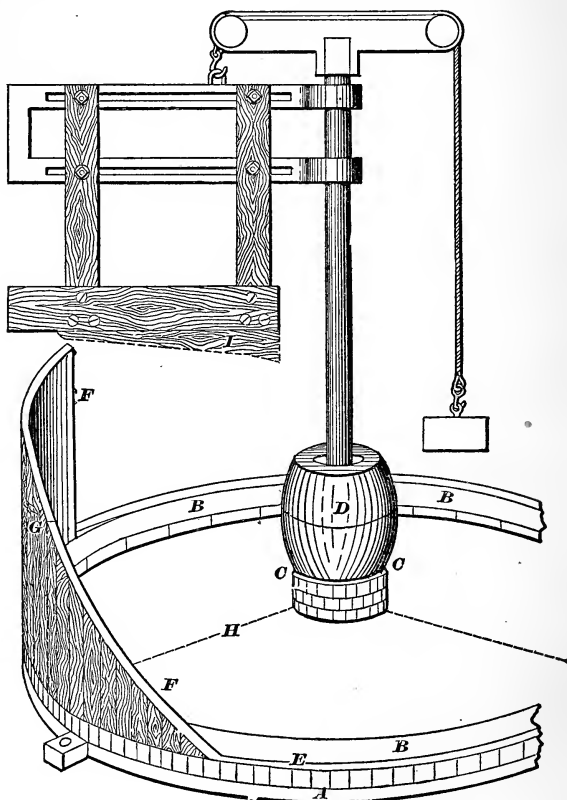


Fig. 176.

As the sweep must travel on inclined frame *F* to give the required pitch of blade, the arms must work free on the spindle, rising and falling on the frame as needed. To accomplish this, a method is shown at Fig. 176, which

is simply a cross-beam, with socket to fit the top of the spindle, with pulleys at the ends, over which a rope travels, to the ends of which the board or sweep and counterweight are attached. The sweep is plain, and must be set in line with centre of spindle.

The first process is to brick high enough for thickness of blade; to do this a guide-piece *I* is screwed on the bottom of sweep, this being a true section of the blade from hub to outside. When all the piers are built to this, remove the piece *I* and build the rest, care being taken to keep the bricks on the outside of blade, and filling the inside with loam bricks made for the purpose, firmly set in soft loam.

You now sweep all the blades true to inclined frame, and as soon as hard enough the form of the blade must be marked off and cut out. Before moving the inclined frame *F'*, mark the centre-line *G* on joint.

You can now bring the sweep-board down to the line, and mark across from centre to outside. This is the centre of blade. Fig. 177 is a perspective view of your mould at this stage, with the three blades built. The lines *A* and *B* correspond to line on inclined frame at *G*, Fig. 176. The lines 1, 2, 3, 4, 5, 6, 7, Fig. 177, are scribed down with the sweep, and are an equal division of section of blade, as shown at Fig. 179. From the centre-line *A*, Fig. 177 is marked off on either side the width of blade; these being connected as seen at Fig. 177, gives the form desired. Fig. 179 shows thickness of blade at the several divisions, with lengths as well. To these sections guides must be made from which to work in cutting out the blade, taking care to have the surface true and even. You must now fill in with green sand, good and hard, giving another coat of skinning loam over all to insure an even and true face.

At Fig. 178 is shown a way to construct the cope. *A* is a plate 7 inches wide,  $1\frac{1}{2}$  inches thick, with hole *B* cast to

secure to plate *C* at *B*, a lug being cast at the other end at *D*, with hole to secure to plate *E* at *F*. Plate *C*, as will be seen, stands on bearings at *G* and *H*, and has bars cast on projecting towards the face of blade, on which to rest and secure other bars, which reach from plate *E* to centre. This plate stands perpendicular, and the bars must be cast on it to suit the forms of blade, and also to clear the

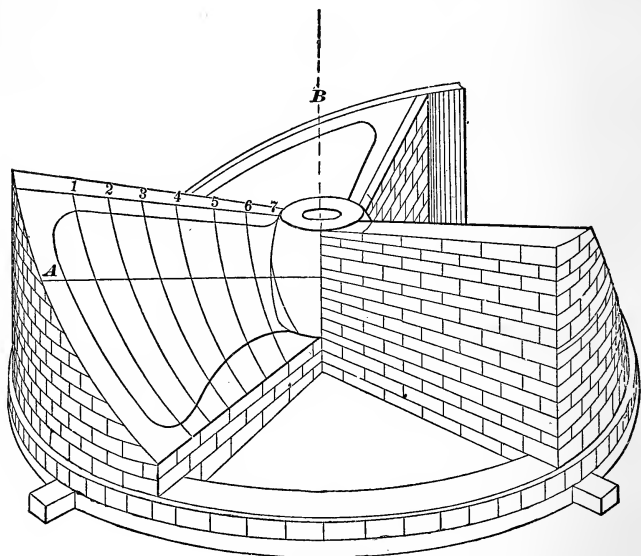


Fig. 177.

hub, taking care that the top lug comes correct at *B*. Plate *E*, as will be seen, has staples cast in through which the bars are put to carry the face of mould.

When the frame is firmly bolted together—on the joint, so as to secure the proper fit—it must be lifted away and clay-washed. Clean the mould, and oil and parting-sand the face; spread on the loam, and bed down the iron.



The bars must now be put in and wedged in the staples, securing the ends at the hub with clamps or wire, as is most convenient.

All that remains to be done now is to fill in the spaces between the bars with bricks on end, packing them in tight with loam, and being careful not to press the ends of the bricks into the face of mould.

If the iron *C* is carefully made to fit the hub, there is little to do but fill up the spaces with brick and loam ; but, as is often the case, the same iron must be used for a wheel of another pitch. Then irons must be used to bind the face of mould to the frame. The copes being all marked, as soon as they are hard enough, can be lifted away. Set them down at *G* and *H*, and tilt back far enough to finish.

About 3 inches or 4 inches of bearing must be made all around top of hub, on which covering-plate will rest, and provision for running and feeding must be made in this plate, the risers being taken off at the highest point of each blade. It will depend on the facilities you may have for drying and lifting your mould how you will now proceed. Should your oven be too small for the large plate, you can place a sheet-iron curb around and build fires between the piers, covering the whole with plates. Another plan is to strike a bearing outside and around the seating at the hub, on which to rest separate plates to carry each blade. By this means both top and bottom of blades can be dried in the oven and set back to stakes or marks, after they are dry. In very large wheels this must be done. In closing your mould, care must be taken to keep the foundation true to the position it was built, as if there should be any warping the wheel would be untrue.

The cross and slings can be used to bind down with, taking care to carry a packing from bottom lug of plate *C* at *J*. Plates may be bedded over the blades and wedged

under the cross. Care must be taken whilst ramming over the blades.

Propeller-wheels are made face down, in which case the

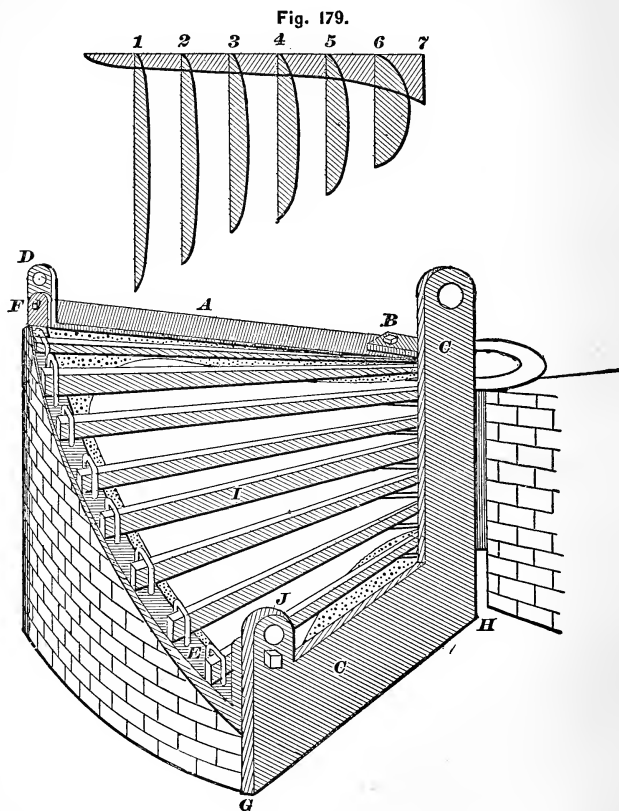


Fig. 178.

first bed is finished off to the plain sweep at once. The position and form of blade is obtained in the same way. The sections 1, 2, 3, 4, 5, 6, 7 are made about 1 inch thick

and placed on the bed, sand being packed between and shaped off by hand to the form of back of blade, and the cope built as previously directed. This plan gives a little more trouble, but it insures a perfect face on the blade, as it takes its shape from the sweep direct, without any fear of alteration from rubbing or finishing.

The instructions here given to mould a screw-propeller have reference to what is called a true screw. There are other kinds of screws made, some with what is called radially expanding and others with axially expanding pitch. But as the question of pitch does not concern the moulder as much as it does the draughtsman and pattern-maker, I shall not intrude the subject here. At the same time I advise every moulder engaged on this class of work to inform himself thoroughly on this subject. By so doing, it will be much easier for him to follow the instructions of the designer or draughtsman.

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## MAKING ELBOWS, BENDS, AND BRANCH-PIPES IN LOAM.

AFTER a long experience on this class of work, and having tried many plans to make pipes in loam, I have concluded that the plan here presented is the best. We will suppose the pipe to be made is in the form of the one shown at Fig. 182, 24 inches diameter and  $1\frac{1}{2}$  inches thick.

First, let your templet be as wide as the outside diameter of pipe wanted, and cast it stronger than you would if needed only for a core. Should you be going to run your pipe on the top, let there be holes cast in plate, through which your gates will pass; for, as will be seen at *A*, Fig. 180, your core-plate is to be the covering-plate. You must also

cast holes over each flange for risers, as well as for the staples shown at *B*, Fig. 180. These staples will be cast in the core-iron, as shown by broken lines at *B*, at such places as are needed for lifting, and, as you will perceive, will protrude through the plate when you set on your core-iron. The core-iron here shown is the best and easiest made of any I have ever used, being readily formed by the use of a bent pricker pattern. It must be understood that in this case you need but one plate and one core-iron.

Before proceeding to ram your half-core, let your plate

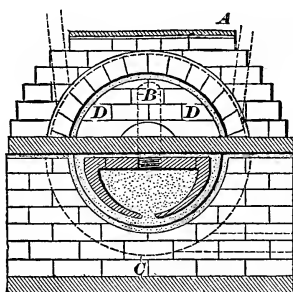


Fig. 180.

be well cleaned, and then lay off the position of flanges, and make marks on edge of plate with a chisel to guide you in setting. Bed down the core-iron, and set in the studs to support core wherever needed, provision having been made, of course, by cross-bars in the core-iron. The position of the stud is seen at *A*, Fig. 181.

Do not, as many try to do, attempt to slick up your core with the trowel after you have swept off the sand, but, what is much better, dampen the face of core and finish off with rubbing-sticks; by so doing you will preserve your core in shape. You must now place on the half-flanges, which are made to fit the core. After squaring and secur-

ing them with spikes, prepare to lay on the thickness, which is done in this manner:

Have a core-box 20 inches long and 6 inches wide, with good draught, the depth of the thickness of pipe. Let this frame be secured to a board. Take the toughest sand you have, moisten it well, and with this make sufficient cores to cover the core inside the flanges. By a little care and practice you will soon be able to cut and place them without much trouble. You must then nail them fast to core, as seen at *B*, Fig. 181. After cleaning away from the stud, the flanges must be taken off and the core dried sufficiently to stand handling, but do not over-dry it, as it must again visit the oven. Whilst the half-core is drying set down the foundation-plate *C*, Fig. 181, and make sure that it is strong enough to stand the handling without springing.

To turn over the core, clamp core and plate together and roll over on soft sand. Remove plate and suspend your core over foundation plate at the place most suitable for lifting and binding, and as much above it as will admit of a brick between it and the flanges, as seen at *C*, Fig. 180.

Now pack up with dry brick to all the bearings, taking care to have your core level; place your chaplet from bottom-plate to stud, as shown at *D*, Fig. 181, and when all is firm and level you can lower off. The chaplet here mentioned is simply a straight piece of  $\frac{3}{4}$ -inch iron, nicked at end which enters casting, which is built in and remains. By this means absolute correctness is assured in thickness when you close the mould.

You have now got your half-core in position for building around, but it is best to put on the upper half. Find place for stud and set it into sweep (see *E*, Fig. 181). You will observe that I have shown, first, the stud, which is high enough to admit of a piece of wood 1 inch thick, 4 inches square, on which is placed a thin piece of wrought-

iron, the idea being to save the trouble of releasing the stud when cast, as by the time the wrought-iron is hot enough to burn the wood the metal will be set, and all danger over of the core lifting. The wood burns away, and allows the shrinkage to take place without damage to casting. *A*, Fig. 182, also shows position of stud. Set flanges in position, top halves as well as bottom. Commence by building behind flanges, as shown at *D*, Fig. 180. Build up to flanges  $\frac{1}{2}$  inch clear of circle, rub on loam and sweep

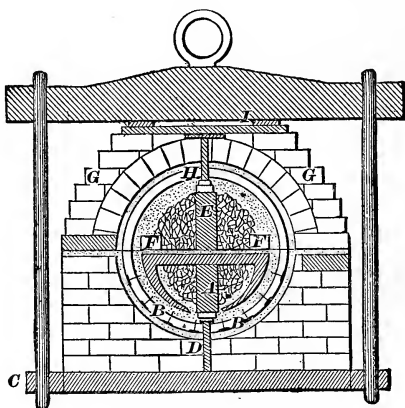


Fig. 181.

off with top half of flange. You may, if you choose, extemporize a bearing for the flange to run on, but very little practice will enable you to do without. You will observe a hole is left in the middle of brickwork for the gas to escape at.

Having now got the ends of core in good shape and your studs fixed, lay (in mud) a course of half-bricks wide apart, as shown at *B*, Fig. 182, about 2 inches from edge of core, as seen at *F*, Fig. 181. Dig down to cinders in two or three places to make connection; fill in cinders, as seen for top

half, packing them well down, and a course of old sand over them to within 2 inches of face, to save core-sand; ram on sufficient core-sand and sweep off. This must be carefully done, as you have only the thickness on which to rest your sweep, but by a little care you can secure a good shape. After rubbing to shape, secure the flanges in position and place on the thickness. There is no need to nail the upper half.

You have now got the core and pattern in perfect shape—in every respect as good as the best wood pattern. Now oil all over, and throw on parting-sand and build up to joint, as shown in Fig. 181, leaving about  $\frac{1}{2}$  inch for loam.

At *C*, Fig. 182, is shown plan of cope-ring, which must be made strong. The ring is made by laying templet on level bed and marking  $1\frac{1}{4}$  inches clear of outside, also allowing good clearance at ends. In bedding cope-ring have it suspended over your mould all clean, and then lay on your loam a little higher than the half. Throw on plenty of parting-sand and bed down the ring; mark, and lift off again. You now go round with your trowel making the joint to correspond with the bottom of ring; this gives you a perfect joint. After throwing on a little more parting-sand, clay-wash inside of ring and put back. Fill in between ring and pattern, and build as shown at *G*, Fig. 181.

I have been careful in making these drawings to show the whole plan of building. At *H* is seen chaplet resting on stud, which reaches just high enough to admit of a flat wrought-iron plate being placed upon it. The mud of course covers this as it does the brickwork when the top plate is bedded on. The broken lines at Fig. 180 show methods of running, the top gates at flanges being the best usually. As you will see, they are set to clear the body core. You now see the use you are to make of the core-plate, and why you make provision for running, etc., when

it is made. The reason for the loose plate over the chaplet is to save trouble when bedding on the top plate. The mud between the plates becoming hard enough to resist the pressure, saves trouble. The top chaplet also remains where it is built, so that when the mould is closed there is no measuring or wedging to do. Mark your mould at the

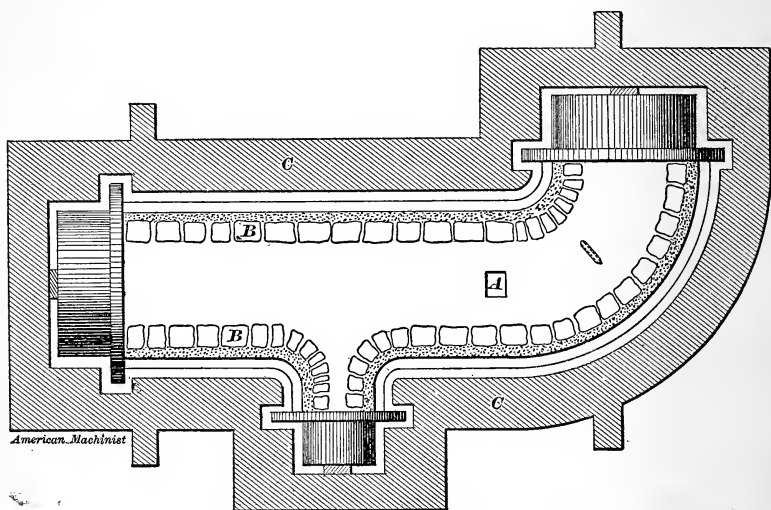


Fig. 182.

joint at such places as are not likely to be disturbed, lift off your cope, and set up on stands high enough to work under. Lift out your core, first freeing it at prints, as well as digging out a little of the thickness all around; this prevents the joint from being lifted up. After pulling off the thickness, and trimming, a little blacking finishes ready for the oven. In closing your mould, if you are careful in setting your bottom half in pit, you will find that core and cope will come together very readily.



A plan of binding is shown at Fig. 181. By hitching on to centre of beam with slings attached to bottom lugs, you can pack between it and covering-plate as seen at *I*, Fig. 181. Fig. 180 is an end view of mould when closed. Fig. 181 shows section of mould cut through at chaplets, and shows how to make both halves of core. The thickness is shown nailed on bottom half, the method of building, binding, etc. Fig. 182 is plan showing bottom half resting on bearings, flanges set and top bearings struck off, with course of half-brick laid ready for cinders; staple is also shown as well as cope-ring.

We will now consider some other methods which will best meet the case, when the order is for a sufficient number to warrant the necessary outlay for casings, etc., by which means the founder can produce castings with greater facility and at less expense.

In order to give a clear exposition of the method of moulding pipes in casings, let us proceed to make a 24-inch socket-pipe, 10 feet long, and bent to 14 feet radius. The succeeding instructions will serve for flange-pipes as well.

Fig. 183 is a sectional view of top and bottom halves of the casings required for moulding such a pipe. The thickness is 1 inch all through, strengthened by ribs, 2 feet apart, extending all round, from flange *A* to flange *B*, as indicated by the outer line. Lugs for lifting purposes are shown at *C*, *D*, *E*, and *F*; these may be either separate or attached to the ribs, according to circumstances. In this instance  $1\frac{3}{4}$  inches is allowed for loam, which is held to the casing by the prickers shown. Let these prickers be  $1\frac{1}{4}$  inches at the base, and  $\frac{1}{2}$  inch at the top, for if they are made any lighter than this their life is short. They may be set in about 6 inches apart, and vent-holes cast in the same ratio.

It will be seen at *G* that provision is made for holding a stud with which to support the core; this socket is made to receive a stud 1 inch in diameter, and must be set in exact position to catch the packing *H*, which, as shown, extends from the surface of the core to arbor *I*. Provision for holding down the core is shown at *J*, con-

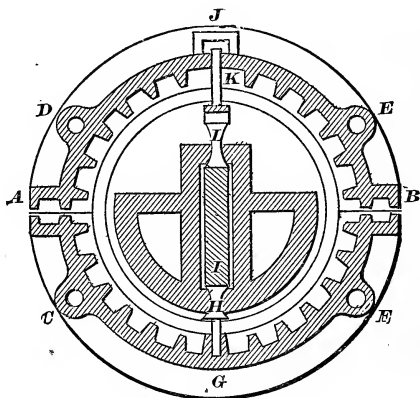


Fig. 183.

sisting of two clamps of wrought-iron,  $1\frac{1}{4}$  inches square, cast in the casing—one on each side of the hole through which the stud *K* is dropped. A stout bar, resting on the stud, and firmly wedged under these clamps, secures the thing at once.

This stud *K* is seen to rest on a wrought-iron plate 4 inches square and  $\frac{3}{4}$  inch thick, and between this and the packing *L* is inserted a piece of wood 1 inch thick, and of the same dimensions as the plate; this wood burns away in due time, and releases the core-iron. Of course the casing is made to the form of the pipe, as seen at section

of socket end, Fig. 184; and it is best to allow 6 inches extra length, as shown at *A*. The core, extending the same distance past the bearing, forms a space into which sand may be rammed all round after the mould is closed; and by this means make it impossible for the iron to escape at any part of the bearings.

The mode of sweeping this mould is shown in detail at Figs. 184, 185, and 186. Fig. 186 represents a frame of cast-iron made to the outer dimensions of the pipe on its inside edge (only at the print ends, which must be the

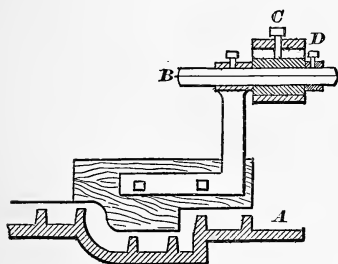


Fig. 184.

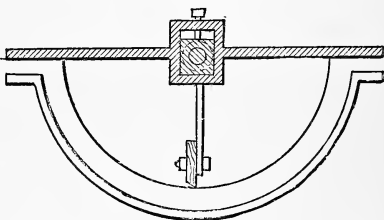


Fig. 185.

width of the core at that place), and whose outside edge corresponds to the casing at *A*, *B*, Fig. 183.

This frame and a body sweep, in conjunction with the spindle attachment shown, constitutes the whole arrangement for forming the outside of the mould.

It will greatly facilitate the operations if the casings are set one on each side of a vertical spindle, with which to sweep off the joints; and should the spindles already erected not be available, one can very readily be extemporized for the purpose. The joints may be rammed with dry-sand facing and swept with a straight board, after which the iron frame is placed thereon, and the mould formed.

It will be seen that the spindle *B*, Fig. 184, works in a

loose bush, which is held in its place by a set-screw *C*, and that it is prevented from moving endways by the collar *D*. The reason for having this loose bush is obvious; the centre of the spindle must be on a line with the joint of the mould, as seen in Fig. 185, and when the frame is reversed and placed on the other half, the bush must be moved to bring the centre on a line with the joint, as in

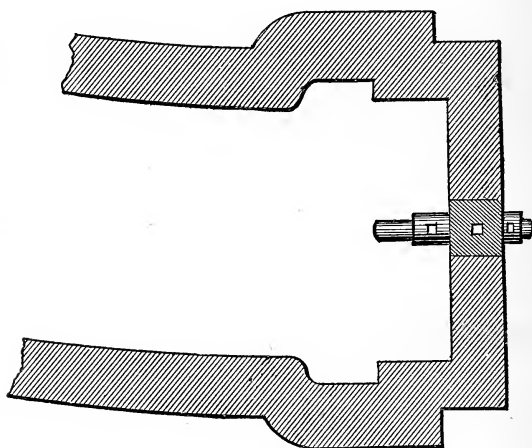


Fig. 186.

the former instance. If this were not done, two frames would be required, and four holes bored instead of two.

The horizontal spindle serves to form the ends, and also the bearings for the core, and, as will be plainly seen, flanges may be swept with the same facility as plain ends. The body of the pipe is formed by a sweep, made to rest on the frame as it is drawn from end to end. By using one frame for both halves an absolute fit is obtained by simply smoothing off the loam even with the outer edge of the frame in both cases, and carefully matching them when closing the mould.

The mode of pouring in this case will be governed by the style of core used. Should the core be made of a material which will allow the iron to be dropped on the top, a sufficient number of holes must be cast in the casing for the purpose of forming the gates. Or, if it is thought best to make the bottom half in dry sand, and the top green, then provision can be made in the bottom casing for the insertion of the necessary gates, and se-

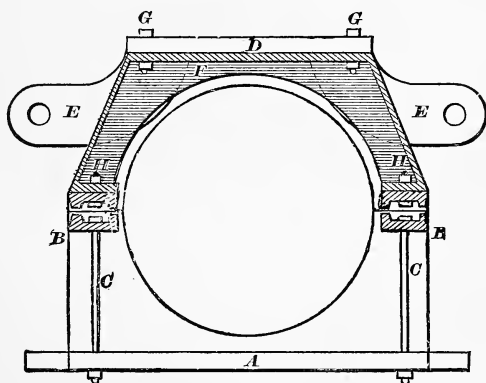


Fig. 187.

curing the runner box in which the pouring basin is to be made.

Again, should an entire green-sand core be used, it will be best to provide for running in at the end by casting holes at one end of the top casing for upright runners to connect with gates cut round the bottom bearing, these again connecting with the casting in the direction of its length. Such a runner is easily made by attaching a finger-piece to the sweep, at the point where it is intended to run the pipe, connecting it with the mould afterwards. The latter mode will be found applicable in nearly all

cases, and is by far the best method, owing to the fact that neither cope nor core offers any opposition to the free ingress of the iron.

The labor of making cores for this job will be appreciably lessened by providing a half core-box of cast-iron in which to make them. When such a box is furnished, all that is needed in the way of core-iron is a stout bar, made to the curve of and central with the pipe, on which loose frames are wedged fast along its length, at a proper distance from each other, as shown in section at Fig. 183. With such a rig as this it is only required to ram about 6 inches of sand solid all round, filling the inside with coarse cinders as the ramming progresses. The top half can be swept off with a strickle, made to work on the edges of the half-box, and any little deviation from a correct half in the iron box can be rectified by adding to or reducing the strickle, as occasion requires.

The utility of the method herein suggested for sweeping pipes is not by any means confined to moulding in casings. By referring to Fig. 187 it will be seen how easily it may be applied to a regularly built mould, so prepared that an almost unlimited number of pipes may be cast therein with absolute safety, the frame and horizontal spindle being used in exactly the same manner as directed for the casing. The inner circle represents the mould, the bottom half of which is built on foundation-plate *A*, up to the points *B, B*, where another plate, which is a fac-simile of the flange on the casing, is placed and secured by bolts *CC*.

For the top half, make the covering-plate as shown with lugs or handles *E, E*, set convenient for lifting and rolling over. Let holes be cast about every 12 inches along each side of the plate, for the purpose of securing cross-bars *F*, which, as shown, have flanges, with holes cast to correspond with those cast in the top plate. Bars and plate are then made one by bolts *G, G*, and similar plates

to those at *B, B* are secured to these bars by bolts at *H, H*. The bars, having a flange along their outer edges, hold

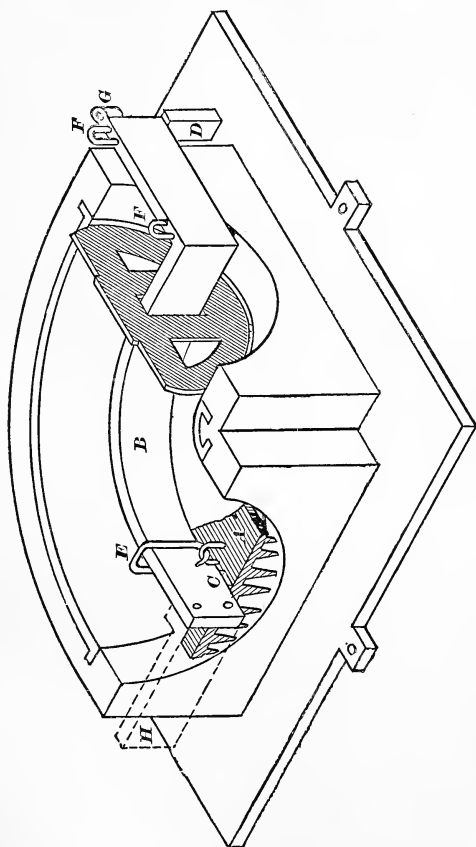


Fig. 188.

the bricks firmly in their place, while the lugs *E, E*, extending beyond the outermost part of the mould, and set central with it, allow the cope to be rolled easily either

one way or the other, resting on them (the lugs) throughout the whole operation of reversing.

Before entering on another phase of this subject, let us revert to the matter of securing cores, and that by means other than by chaplets and studs. It is not always essential that studs be resorted to as a means of securing cores, as we shall demonstrate further on.

Fig. 188 is a mould view of a 48-inch elbow-pipe, whose flanges are equal distance from the centre, and at right angles to each other. The mould is supposed to have been swept, by either the frame suggested or by any of the customary methods in vogue, and the thickness laid, ready for building the core. Ordinarily, the plate *A*, after being swept on the underside and dried, would be turned over and laid on the thickness, and a middle stud cast on the plate would rest on another one, set to match it in the bottom of the mould. Now this, as well as all the labor in connection with the holding down of such a core as the one under consideration, can be successfully done away with, by using the bar with counterbalancing ends, shown at *B*, Fig. 188. In the case under consideration this bar would rest on packings at the ends and middle of the plate, one of which is shown at *C*.

The plate *A* can then be secured to the bar *B* by clamps, after the manner shown at *E*. The whole job is then controlled by the counterbalance; inasmuch as it is lifted by staples *F*, *F*, prevented from drooping by bearing *D*, and held down by securing at *G*. When these bars cannot be taken out whole, one end may be made separate and bolted on, as shown by broken lines at *H*.

It will be apparent how readily this principle can be applied to a dry or green-sand core by slipping on the thin plates *I*, as before directed.

When the radius of the bend is not too small, and the



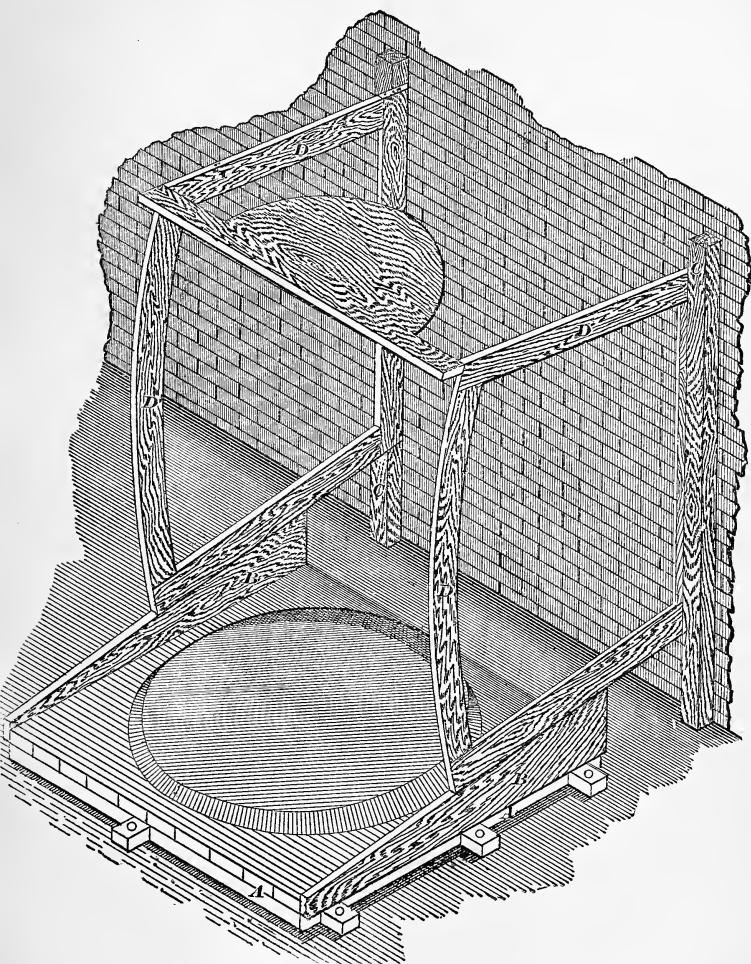


Fig. 189.

pipe within limits as to length, it becomes practicable to mould and cast such on end, as the following will show.

Let it be required to make a 48-inch pipe, 8 feet long, and radius of bend 34 feet. First lay down a suitable foundation-plate, as shown at *A* (Fig. 189), and with the spindle sweep thereon an ordinary seating a little larger than the outside edge of the socket or flange; in this case

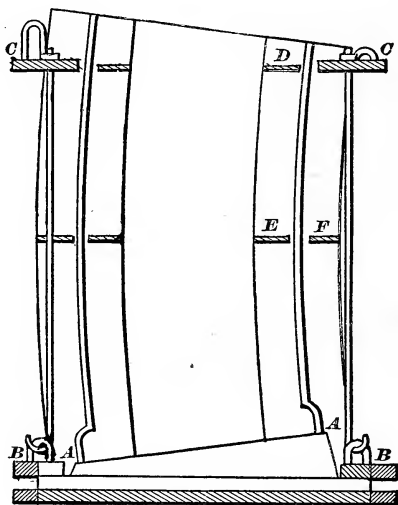


Fig. 190.

it is socket; but, as before stated, these instructions will serve in either case. When this has sufficiently hardened, set the guide or angle pieces *B, B*, with which to finish off the bed to the required angle, as seen at *A, A* (Fig. 190).

A careful examination of the view given at Fig. 189 will reveal the whole plan of operation; *CC* are posts made fast to the wall against which the guides *DD* are screwed fast, at the same time resting on the angle-pieces *BB*.

The top and bottom edges of these guide frames correspond to the angle of the ends, and the front edges to the curve of the pipe; these are placed exactly midway of the mould and form the bearings on which the strickles work

Fig. 191,

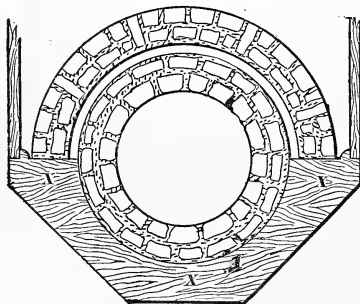
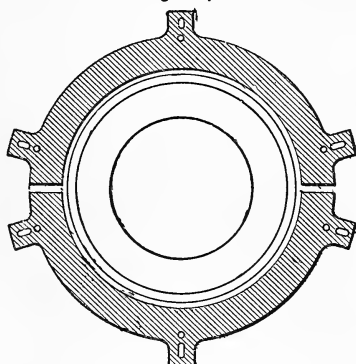


Fig. 192.

to make the mould by. The first strickle used is shown resting against these bearings at *EE*.

The socket or flange (which may be segments of cast-iron or wood) being placed in position, the first half of the cope must be built. The half-rings for carrying the cope

are shown in section at *BB* (Fig. 190). The top halves are shown in plan at Fig. 191, and also in section at *CC*, Fig. 190. The arrangement for bolting and lifting these half copes will be manifest without further explanation other than a careful study of the drawings will convey. A few half-rings for binders will be necessary in both copes and core, as seen at *D*, *E*, and *F*, especially so when the curve is quicker.

The plan view at Fig. 192 shows first half of cope built, thickness set against it and the core built up to this thickness at the inside half, and swept by the strickle *A* on the outside. If the strickles should be found too heavy for easy working, fix a rope pulley overhead and hitch on at the place marked by the crosses, and be sure to have the block pull hard against the guide; by this means the working will be better controlled.

The job is now completed by adding the socket and thickness (around the core this time, of course), and building the other half of the cope.

It is best to place the halves together for finishing, and any bead or facing which may be called for on the top end may then be formed by a finger-piece worked round to a circular guide resting on the joint.

Should the pipe require flanges at both ends, segments can be used top as well as bottom. It hardly need be said how simple a matter it will be to build in a branch at any part of this mould.

When practicable, this method will be found far in advance of any other for this class of work, as it saves both time and expense, and requires less skill to work it.

## MAKING LARGE ELBOW-PIPES ON END IN LOAM.

VERY large elbows are usually made in as short lengths as possible, and very rarely exceed a quarter of a circle, in which case they are readily made on the flat. But when, as is sometimes the case, a pipe is required, say 60 inches diameter and 8 feet long on one end, a much better way can be found to make it. And as the instructions for this job will serve for almost any other having a large elbow cast on, I have taken pains to show every detail of the operation. A careful study of the engravings is almost all that any intelligent moulder will require to enable him to grasp the idea. But as my object is to instruct such as have had little or no experience in this class of work, I shall take the job in detail and explain from beginning to end how to make an elbow-pipe 5 feet diameter 3 feet 6 inches and 8 feet 6 inches from centre of elbow.

First. Let cope and core of long end be built and swept in the ordinary way, with sweep and spindle up to the turn shown at *A*, Fig. 193. The outer lines of Fig. 194 represent plan of foundation-plate and cope-ring. At *B*, Fig. 193, is seen the binding-ring for cope, which is cast to outside dimensions of brickwork, and extending at the front the same distance as bottom cope-ring, and wide enough to permit the guide-pieces *A*, Fig. 194, to rest on it. A smooth bed of loam is struck at joint *A*, Fig. 193, on cope and core.

Now let these plain parts be closed together in the pit, and as you must work around your mould, cover the mouth of pit with planks. Fill up the thickness with waste or hemp, and lay on the guide-piece *A*. A side and end view of this guide is shown at Figs. 195 and 196. The half-flange must be attached to this guide at its proper

distance from centre, and the whole frame set to centre-lines drawn on the level bed, as shown. The sweeps for forming the elbow will run on these guides, with stops, as shown at *A*, Fig. 196, and after the outside is built, as at Fig. 196, the thickness must be placed on and the core built.

Figs. 193 and 196 are side and end elevation of core, and show the way to construct it. At *A*, Fig. 193, is seen the bottom plate, having staples cast on the upper side, to bind

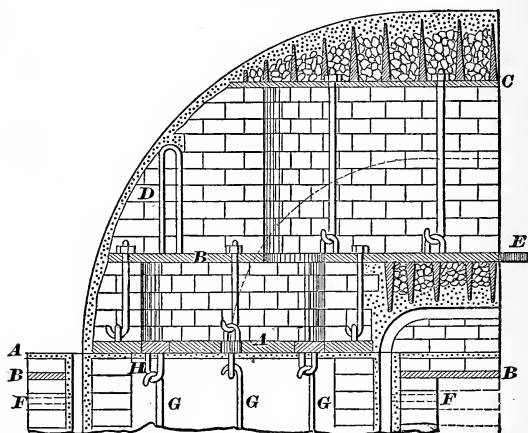


Fig. 193.

the plate *B*. These staples are shown in plan, Fig. 194, marked *I*. Four internal lugs are cast on this plate, with staples cast downward; these, as will be seen, are used to bind the core to foundation-plate, in which corresponding lugs must be cast. This method of securing the elbow to the body core does away with the use of chaplets, and makes the job absolutely safe as regards metal oozing through the joint.

Let this plate be solidly bedded on the joint, as shown, with no loam under it; set in the hook bolts, and build up to *B* with an ordinary double course of brick, using the

reverse sweep on guide, as shown. By referring to Fig. 196, it will be seen why this brickwork is carried so high. It allows of a sufficient width of plate to carry the sides of core, which, as is seen, is built on plate *B* as far as plate *C*. It will be seen that plate *B* has not only holes cast in to

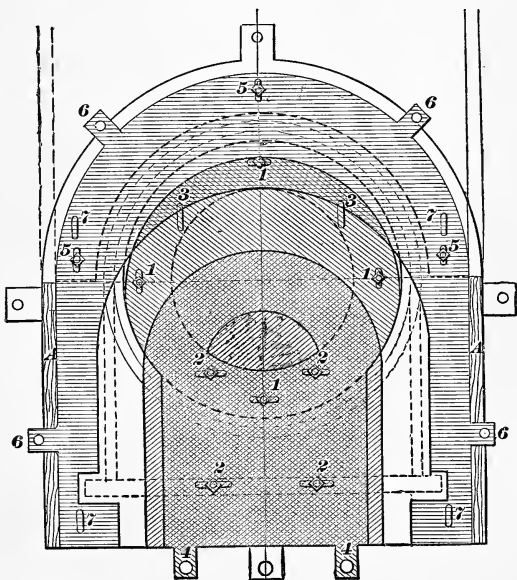


Fig. 194.

receive bolts from plate *A*, but other staples are shown, which serve to secure the top plate *C*, and so bind the whole core together. These staples are seen in plan Fig. 194, marked 2. The long staple *D* and lugs *E* are shown in plan at Fig. 194, marked 3 and 4.

Let this plate be turned over after it is made, and after filling in the cinders about half-way of the pricklers, fill up the rest with loam and pieces of brick. If you are careful in making the plate to push the pricklers in the right

length to suit the curve, a very thin coat of loam will serve to bed down in. When this is dry enough to use, bed it into place and secure the bolts from plate *A*, and build, as shown, up to where plate *C* comes on. Holes are cast in plate *C* to correspond with staples in plate *B*. This plate, with holes marked 2, is shown in plan at Fig. 194.

After securing plate *C*, fill in cinders among the pricklers up to within 4 inches of face, and ram over this plate with good open core sand. The brickwork can be strickled off with loam in the usual manner.

The reason I prefer core sand for the top is because the iron rests more quietly on sand than it does on loam. Before striking off the sand be sure and vent well down into the cinders. It is important that you should have as many holes as possible cast in these plates, to carry off the gas, and also have the brickwork as open as possible, and well cindered in every course. After finishing the core let the upper half of flange be set on true, and put on the thickness. Oil all over, and throw on some parting sand; you may then proceed to build the outside.

At Figs. 195 and 196 is seen the way to build it. *A*, Fig. 195, being the first plate needed, staples are cast in this plate for the purpose of binding it to plate *B*. A plan of plate *A*, with staples marked 5, is seen at Fig. 194. The overhanging brickwork can be supported with a building-ring or plate, as shown at *C*, Fig. 195. Plan of plate *B*, with holes for bolts from *A*, and staples marked 7, carrying bolts to plate *E*, with lugs for lifting, marked 6, are seen at Fig. 194. A method of building this part is shown at Figs. 195 and 196, with top covering-plate *E* bolted down.

After all is built, and the requisite marks made for guides, the top can be lifted away. Dig out about 2 inches down of the thickness, to save pulling up the joint, and then lift out the elbow core. The thickness being cleaned out of the bottom half, and the waste or hemp removed from



around the mould, you can—after making sure of guides at the bottom seating—again separate your moulds and finish for drying. Should it be found inconvenient to handle the whole cope when the under half of the elbow is built on it, or should the mould be too long for the oven, the plain part can be divided by an extra cope-ring at any point you may choose.

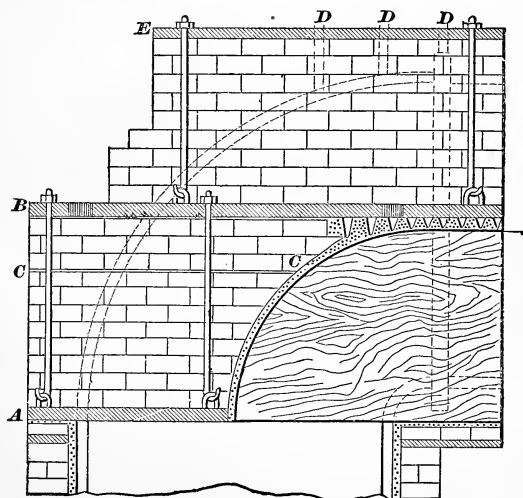


Fig. 195.

The rest of the job is plain, each piece finding its own place in the order they were separated. After the elbow core is in place, the bolts *G*, Fig. 193, must be secured, as already explained, to the foundation. A little of the dry loam may be scraped out at the joint *H*, Fig. 193, and wet loam pushed into the space, as shown.

Should there be any doubt as to the strength of building-ring *B*, Fig. 193, piers can be built up from cope-ring to support the front, as shown by broken lines.

To gate such a casting as this, let the bottom flange be covered well by runners leading thereto, before you rise up to the main runners, which are shown by broken lines at *F*, Fig. 193. As many of these runners can be put in as will run the casting at a fair rate of speed until the iron reaches about the height of the plain part, or even a little below, when runners *D* at top flange, shown at broken line, Fig. 196, must be used.

If two ladles are used to cast with, all the better : a sep-

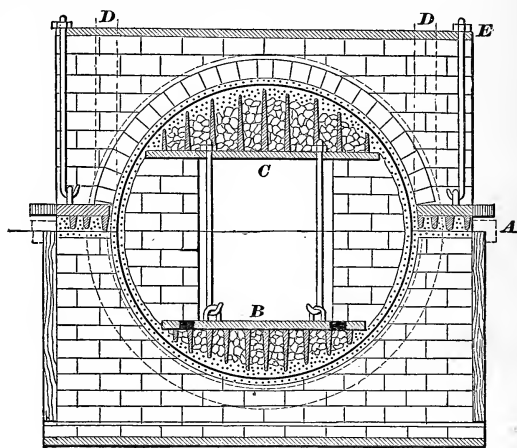


Fig. 196.

arate runner can be made for them ; but should only one ladle be thought necessary, let plugs covered with loam be inserted in these gates, and the runner made around them, withdrawing them in time to let in the hot iron to the top of the mould before the scum, which rising as the body fills up, reaches the elbow part.

Broken lines at *D*, Fig. 195, show the risers.

The vent can be taken from this core by dropping dry shavings to the bottom of core and running a little molten iron down to ignite them just before casting.

## PART IV.

### *DRY-SAND MOULDING.*

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#### DRY-SAND MOULDING, WITH EXAMPLES FOR MAKING DIFFERENT CLASSES OF WORK.

THE term “dry sand” is somewhat indefinite, and fails to convey the full meaning of that which it is intended to explain.

The difference between dry sand and green sand is simply this, that moulds prepared by the latter method are cast at once, whilst in a green or moist condition, and the former are dried in ovens, built for the purpose, before the casting takes place.

The reasons for the drying process are many, as will be shown farther on ; and whilst it must be confessed that very many castings are made in dry sand at an augmented cost, which might as readily be made in green sand, still I am persuaded that the system would be more generally adopted for a larger range if it was better understood.

The extra cost of production is sometimes urged against the adoption of this method, but this cannot always be substantiated, as very many jobs, apparently insignificant, might be made with much greater facility and despatch in dry sand than could ever be attained in green sand, with the percentage of loss very much in favor of the former.

It must also be understood that the possibilities by the dry-sand method are not confined to the production of steam-cylinders and kindred jobs, but can be made of universal application.

Difficulties almost insurmountable, if attempted in green sand, disappear at once when it is decided to make the job in dry sand; and large numbers of castings which, if made by the former method, would require the very best talent to produce, may be accomplished by the latter with comparative ease by inferior men.

A dry-sand mould correctly prepared is a much firmer mould than could possibly be made in green sand, for which reason a greater resistance to pressure is offered by it, thus enabling us to accomplish very deep work without detriment to the outline of the mould.

It is because of the greater opportunities for first-class finish which dry-sand moulding offers that we recommend its adoption on all work of elegant design, when a correct reproduction of the pattern is demanded, whether the job is to be tool-finished or not.

Again, a dry sand mould, having lost its moisture, is more porous, and consequently requires less labor in preparing a way out for the gases generated on the surface of the mould as the molten iron fills the space; in fact, when the mould is thoroughly dried, which ought always to be the case when best results are called for, the need for venting is reduced to a minimum, except in such parts of the mould as are very much confined.

This being admitted, there is less danger of the mould scabbing, and thus endangering the success of the work from the presence of dirt resulting therefrom.

It must also be remembered that scabbing is not the only cause of dirt in green-sand moulds; for, no matter how carefully such a mould is prepared, the surface suffers in proportion to the wash of the molten iron upon it, and

gives off an amount of dirt, which goes to increase that of which we have already spoken.

Now this, as previously intimated, cannot occur in the well-prepared dry-sand mould ; this fact alone will be sufficient to recommend the latter method for the production of all castings which must be clean in their upper as well as more remote parts.

Another advantage which this method offers is that moulds may be poured with much hotter iron without detriment to the surface of the casting, all the superior finish being preserved intact—a highly desirable thing in very many castings, it must be allowed.

This is certainly a very great advantage, for it is well known by all practical moulders that a much better surface can be obtained on the green-sand casting if the iron is allowed to cool down to the point where it will be just able to run smoothly, and fill every part without showing faint outlines at the sharp angles; but is it not also admitted that, by cooling the iron to save the mould, such iron has in some measure lost its fluidity, thereby lessening its ability to flow together in one compact mass? Especially is this the case where there are portions of the mould of less magnitude than other portions, the lighter parts, in this case, having to wait, as it were, until the heavier parts fill, become partially or wholly congealed, and, on account of the dulness of the iron, the connection is lost at that part, and very often the casting as well, on account of it.

There being no necessity to dull the iron for a dry-sand mould, the above serious error is averted.

This, however, is not the only way by which hot iron may be permitted to assert its superiority over dull by adopting the dry-sand method; it must be apparent to all that dull iron has also lost its ability to throw off its impurities. Entering the mould in a sluggish stream, or streams, it forms a convex upper surface as it rises in the

mould, and such impurities as appear on its surface are laid against the sides, lap on lap, as it were, whilst, on the other hand, when good hot iron is used, its fluidity being greater, the dirt rises instantly to the top, and is carried to the point prepared to receive it, leaving the casting comparatively free from impurities, as well as preserving a degree of homogeneity in the mass, only to be attained by such practice, and no other.

Right here let me say that the soundest castings are those which are poured with the hottest iron; therefore, to obtain them it is imperative that such moulds be prepared as will admit of iron being used in that condition. This, I think, is a very strong argument in favor of dry-sand moulds for all work requiring the maximum degree of strength and purity.

Still another important advantage which a dry-sand mould possesses, namely, that castings may be gated, or the iron may be introduced into the mould at such places as will be most likely to secure a good clean finish, if it should be desired. This cannot always be done in green sand, except in a very limited number of cases, simply because the surfaces of the green-sand mould are not as firm as they are in dry sand; consequently the first thing to determine, if the job is to be made in green sand, is not, "How can we best secure a clean bore or planed surface?" so much as, "How can we best avoid scabbing of the mould?" and nine times out of ten the gates are placed with the view of meeting the latter emergency at the expense of the former.

Very true, a great number of green-sand moulds may be tilted to the angle suitable for clean pouring, and even set on end for the same purpose; but, as I said at the outset, greater skill and considerably more time is needed to accomplish this, and the risk of losing the casting is always greater.

It might be asked, if the dry-sand method is so much superior for intricate and heavy work, why is it not more generally adopted? The correct answer to such query would be, because it is not generally understood, and is underrated because of failure in some instances when it has been attempted by men who were unaccustomed to such work.

For the successful accomplishment of this class of work, men must be trained to its performance, the proper material, the best tools, such as flasks, ovens, pits, etc., must be provided. When this is done, it is safe to say that, with right management, the output may be made in every sense superior to anything which could be effected in green sand.

#### MOULDING SANDS AND CLAYS.

One of the chief elements for the production of good dry-sand work is the sand used for facing the pattern with, and as some jobs—such as are rammed on end with a very limited amount of sand between the pattern and the flask—do not allow of such facing, but must be filled up altogether with the same sand, the whole heap in this case must partake of the nature of facing sand.

This sand should possess a uniformity of grain, with sufficient cohesiveness to allow of its being packed or “rammed” into a compact mass; this does not mean that it shall be of a pasty nature; for, usually, the element which creates such a condition is something which detracts from its value as a good moulding sand.

It is important that all sands for moulding purposes should be as free as possible from such substances as will generate gas when subjected to the great heat which is brought to bear on them, and for the same reason they must be chosen with regard to their fusibility.

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Very frequently it is possible to use some of the finer grades of sand, of a not very refractory nature, on thin castings, and by so doing obtain smoother work; but if such sand were to be used on heavier work, failure would be the result; success in the former instance being attributable to the simple fact that the molten iron congeals rapidly, and loses its power of penetration, whilst in the latter it remains longer in a fluid state, thus giving time for the fusible substances in the sand to melt.

From the above, it will be inferred that, in some instances at least, inferior grades of sand may be used with impunity at considerable saving of cost in manufacture, whilst again, in other instances, the selection of the most refractory kinds of sands is indispensable.

It is not desirable that good moulding sand should contain very much of any other element than "silica," which is simply "flint-stone," or "quartz," this substance being the most refractory of any of the rocks or earths; but as found in the various sand-beds from which it is dug, it is always mixed with more or less of other matter, which impairs its value for foundry purposes; but it is claimed that a little "magnesia," or oxide of magnesium, together with a small percentage of "alumina," or oxide of aluminum, improves its value.

The clays used for bringing the silica up to the requisite degree of consistency must be carefully selected, as all such as contain more than six per cent of "carbonate of lime"—commonly called "limestone"—should be rejected.

It will be seen from the foregoing that, in making selections of sands and clays for moulding purposes, it is absolutely necessary that some one should possess a sufficient knowledge of chemistry and geology to enable him to not only choose the right kind, but to analyze the same after its identity has been thoroughly established; otherwise we must go on in the old way, making repeated trials of differ-

ent sands, etc., mixed in varying proportions, and by so doing obtain such mixtures as, at best, are only an approximation to correctness.

Does not this suggest to us, as moulders, the great necessity of a higher education, to enable us to know *all* of our trade?

### FLASKS.

Flasks for dry-sand work should always be made stronger than is usually the case for green-sand, because of the harder usage they receive. All joint edges should meet with chipping strips as thick as will separate the flanges wide enough to allow of a loam packing being pressed in before bolting together.

The method of having this chipping strip extend to the outer edge of the flange, alternately, between the bolt-holes, with the view of supporting the flange against the pressure exerted by the bolt, is not a good one, as it interferes with the safe stopping-in of the joint; very often castings are lost on account of the metal finding its way to this spot. It is especially dangerous when the mould is to be placed on end in a confined pit.

The better plan is to tie the flange to the body of the flask by at least as many brackets as there are bolt-holes, taking care to have each bracket as close to the bolt-hole as possible, after the manner shown in the flask drawn at Fig. 197.

All cheek and end parts, where practicable, should have holes cast in them, for the purpose of bolting in such bars as may be required to check off separate parts of the mould; and as, very naturally, these holes weaken the sides very much, it is well to still further strengthen them by cross-flanges extending from edge to edge in as many places as it is convenient to do.



ever it is tried on such work as “pumps” and “cylinders,” I have no hesitation in saying that it is a comparative failure, for the simple reason that such sands are too fine in the grain, give off too much gas, and are lacking in the one great essential—“stability.”

Because of its fineness, it is wanting in porosity, and must therefore be treated in much the same manner as in green sand, every part receiving its due share of surface venting, etc. All this is unnecessary when a proper mixture is made; therefore, to use such facing sand is an absolute waste of time, to say nothing of the constant danger from scabbing after all this has been done to prevent it.

Another objection to this sand is the rottenness of the surface after it has been dried; and as dry-sand moulds, such as those above mentioned, must of a necessity receive harder usage than is ordinarily the case during the operation of closing, broken spots and patches are the rule, and not by any means the exception.

The No. 5 mixture given in article on “Core-Making,” is all that can be desired for such work, there being eight parts of coarse “silica” sand to two parts of a finer grade of good moulding sand. The finer sand just serves to form a bed, as it were, for the large grains of refractory silica to rest in; but it is these coarse grains which find their way to the pattern during the operation of ramming, thus offering a firm and unyielding surface, which no amount of ordinary treatment in finishing and closing can destroy.

The clay in this mixture serves to cement the mass more firmly together without deteriorating, to any appreciable extent, its porosity, whilst the flour serves a double purpose. First, it gives a greater degree of consistency to the whole, in the green as well as in the dry state, especially so in the latter, if the mould is dry and not burned; and second, whilst there is not enough flour in the mixture to impair its ability to resist pressure and heat, there is suffi-

cient used to make it more easy to clean the casting after it has burned away.

Such a mixture allows for the maximum amount of ramming, and, only in very confined parts, no venting, unless it be done with the view of helping to carry off the steam during the process of drying.

Too frequently we see the same amount of time and care expended to secure hanging sand in dry-sand moulds as must be spent on green-sand. This, of course, is a sheer waste of time. A little reflection will reveal the fact that, allowing the mould to remain, whilst drying, in the same position as when finished, very few of the green-sand methods of gaggers and irons are needed, simply because it requires considerable pounding to break it apart when once it is properly dried, and for these reasons considerable latitude is allowed in the choice of help for ramming up dry-sand work.

The above mixture allows for the blackening and finishing of the mould while in the green state, and, as it is impossible to damage this stony surface by too much sleeking with the tools, there can be no excuse for not producing the most elegant finish.

For pipes, hydraulic cylinders, rams, guns, and all castings rammed on end, in casings which allow for just sufficient sand to make a safe job, the sand must necessarily be all of one heap, composed of exactly the same ingredients, minus the flour, the latter being superfluous for such work, because, the surfaces being all plain, and the distance from the casting to the outside being very short, the gases generated on the surface pass quickly away, and inasmuch as there are no sharp angles or confined parts to break the surface, such work usually skins clean if the proper blackening is used. Of course, constant renewal is necessary to keep this sand up to the right consistency.

## TO MOULD A STEAM-CYLINDER IN DRY SAND.

IN order to make the subject of dry-sand moulding intelligible to those who are not conversant with this branch of the trade, it will be necessary to take a few leading jobs, choosing such as will bring out in detail, the leading principles involved in the production of all such work.

The chief object aimed at by this mode of procedure is not the mere description of how such a job is made, but rather to inculcate such principles in the mind of the reader as will enable him not only to apply them, when learned, to other jobs, but will also help him to think for himself as to how he might accomplish the same end by means perhaps widely different, but equally safe.

Fig. 198 is a horizontal section, Fig. 199 side elevation, Fig. 200 cross-section, and Fig. 201 front elevation of the cylinder we propose to mould. Its chief dimensions are 30 inches diameter and 6 feet long.

It will be seen that the exhaust is placed at *A*, Fig. 200, and that the cylinder is intended to be secured to its foundation by the bearers or feet *B* and *C*, which extend the whole length of the cylinder.

We first determine that it shall be cast on end, with a "head" or extension, cast on the top end, to receive the sullage which always gathers in the mould as the metal is poured in. A careful inspection of Figs. 197 and 202 will enable the reader to see the whole plan of operations required to bring the mould to this advanced condition.

Contrary to the generally adopted method of moulding cylinders on the side, I have, for special reasons, preferred to show how to mould this one with the steam-chest down and both bearers in the cope. This, as will be seen, neces-

sitates the use of a three-part flask, as shown at *B*, *C*, *D*, Fig. 197 and 202.

Should it be thought desirable to carry all the sand in the cheek by the use of bars, as seen at Fig. 203, then there would be no need for the lifting-plate *E*; but the latter will be found a very useful adjunct to the rig, and saves

Fig. 198.

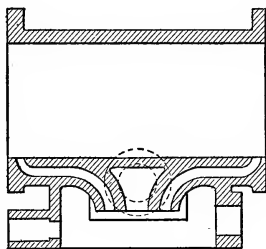


Fig. 200.

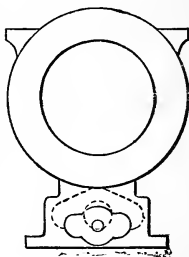
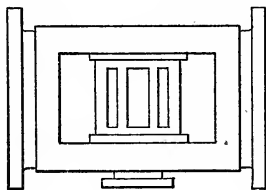
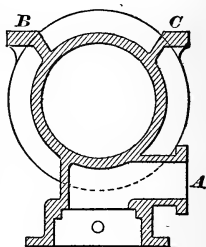


Fig. 199.

Fig. 201.

considerable expense and time when it can be substituted for the bars spoken of.

The manner of ramming cheek and bottom flask when the plate *E* is used is to set the bottom half of pattern on a face-board with the steam-chest up, place the cheek over and proceed to ram, securing all overhanging sand, as indicated by *F* and *G*, by the insertion of irons reaching from the box inwards, as shown. All such parts as exhaust



branches, stuffing-boxes, etc., can be more easily rammed and secured by using the plate in this case; but the bars,

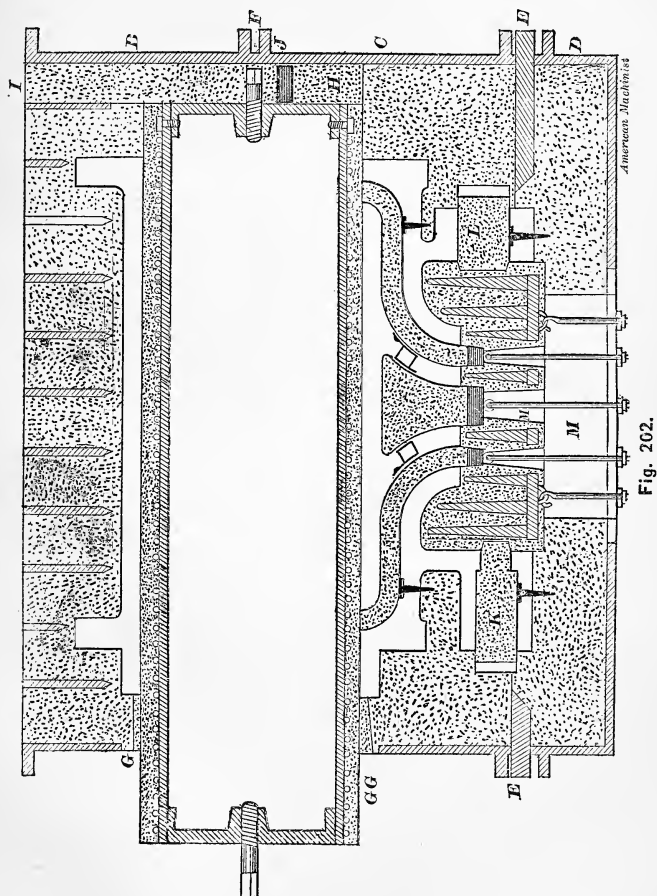


Fig. 203, will be found to be indispensable in many other jobs.

In making plate *E* it will be seen that it allows for the

parting to be made at the upper edge of the steam-chest flange. This places all of the flange in the bottom flask, and will be found an important feature when setting in the steam-chest core.

When the cheek is rammed and the plate firmly bedded down on the sand and bolted to the cheek, as seen at *E*, Fig. 197, it will be seen that the only portion of parting which requires to be made is from the edge of the plate to the edge of flange, after which the bottom flask is placed and secured, as shown at *E*, *E*, Fig. 197, and the ramming completed.

After rolling over the two lower boxes and making good

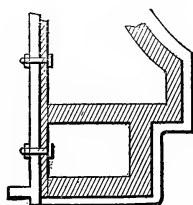


Fig. 203.

the joint, set in position the two arbors *H* and *H*, which are made to carry that portion of sand between the joint and the under side of bearers *I* and *I*, Fig. 197.

By referring to Figs. 204 and 205, it will be seen that these arbors are made so as to rest on the ends some distance past the flange of cylinder in both instances. Fig. 204 shows one end of pattern and sectional elevation of arbor set in position, and Fig. 205 is plan of the same. As will be seen, provision for lifting with the cope, and separating when the latter is lifted off, is made by casting a nut in each end.

The points of separation are made at the ends by the slanting bar *A*, Fig. 208, and along the back, as seen at *H* and *H*, Fig. 197.

I am aware that a block-print and core will accomplish all that the arbor does for this job, and is to be preferred in some instances; but I deem it well to introduce the arbor here, as it will be found to be a very useful device in general practice.

In making patterns for such a job as this, it will be found best to have the two halves of the body separate from the

Fig. 204.

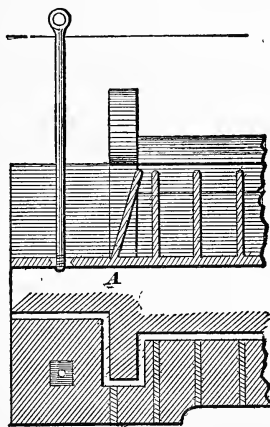


Fig. 205.

rest of the pattern, bearers in cope, steam-chest, and all other appendages being secured to them by screws from the inside.

As will be seen at *F*, Fig. 202, the lower end of cope and cheek are made closed edges, whilst the head end *G*, Fig. 202, is made open, to allow of the body core passing through a distance sufficient to form the runner basin around it, the gates being cut direct from the outer edge, as shown at *G*—the larger one, seen at *GG*, being the riser.

The practice of cutting a main runner around the upper

core-seat, through which the iron passes from one large leader, and from thence into the casting at intervals all round, is not a good one, as it is more than likely that most of the iron, if not all of it, is absorbed by those nearest the leader, the dirt, of course, following in its wake.

It is to obviate this bad feature of running that the method shown at Fig. 202 is advocated, because it allows of the main runner being made all round the core, and entering the mould at as many places as possible, always taking care to miss such cores as connect with the body, and thus assuring a thorough breaking up of the scum as it rises during the process of pouring.

How to make the body core, as shown in Fig. 202, is fully explained in article on core-making. One special feature in these barrels, however, is that the lower end of barrel may be made so as to close in the end by having a solid plate on that end, the top to be the same as shown at Fig. 123 of the article quoted. The object aimed at by this device is to secure absolute safety by making it impossible for any of the molten iron to find its way to the inside of the barrel.

To secure the lower end in all other respects, it is shown that the seating is cut clear to the box end, as seen at *H*, Fig. 202. When closing, the body core is kept back from the box, to allow of a ramming of sand behind, which ramming is continued after the cope is closed over through the space *I*, which is left open for this purpose.

To prevent the barrel from slipping when the mould is turned on end, the packings shown at *J* are inserted.

In making the bottom flask *D* the bars must be arranged after the manner shown at Fig. 206, the central space to be as wide as possible, so that easy access may be had to all the vents and staples connected with the cores.

At *J*, Fig. 197, is shown a space dug out, to allow of the exhaust flange being withdrawn. This, of course, is the

only way of reaching this flange when the exhaust branch is made after this manner, and can only be dispensed with by the use of block cores, either rammed against the pattern or inserted into suitable bearings after the withdrawal of the pattern; both of which modes are objectionable, on account of the seam produced at the junction of the mould and core. When it is practicable, as in this case, the method herein described is the best.

The space *J* is to be packed with sand after the core-

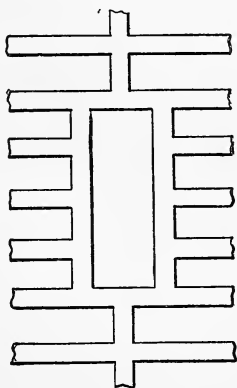


Fig. 206.

cake *K* and exhaust core *L* have been permanently fixed in their true positions.

Cores *K* and *L*, Fig. 202, are to be kept in the spaces shown behind them until the cheek is closed over the steam-chest core, when they can be drawn forth into the seatings prepared for them in the chest core, as seen; and, as these cores must be held in position by packing in sand behind them, provision must be made for that purpose, either by having holes in the end of the flasks, or by cutting down to them from the joint at the most convenient place.

## CORES FOR MOULDING STEAM-CYLINDERS IN DRY SAND.

THE subject of cores will now occupy our attention; and let me say here that too much importance cannot be attached to it, as too frequently we see disaster attend the using of cores which have not been intelligently made.

Ordinary cores are not to be thought of for this class of work. The risk is too great: very many dry-sand as well as loam moulders refuse to use cores except those made by themselves, and unless the very best skill be employed to produce such cores, they are perfectly justified in the course they pursue.

It is my purpose, in describing how to make a set of cores for this cylinder, to give rules which will meet all the requirements in the simplest possible way; and while some of them may not be new to men of a wide experience, it is safe to say that to countless others in the trade they will prove valuable information.

The steam-chest as well as the ports and exhaust cores are shown in position in Figs. 197 and 202; a careful examination of the cuts will show how the chest core is made, as well as how best to secure it in its place.

The grate or "core-iron" is made with prickers reaching into all the remote parts of the core, care being exercised to leave an open space opposite each of the three cores which are set on it in their respective seats; the sand between these seats is held firmly by the prickers shown. Sufficient bearing is left at the ends of each seating on which to rest the ports and exhaust cores, and it will improve the job very much if these bearings are made by setting in iron bear-

ings when the chest core is made. It will be seen, also, that staples are cast into the chest core-iron, with which to bolt the same firmly in its seating, as shown at Figs. 197 and 202.

To make port cores have the core-box made open, as shown at Fig. 207, with end pieces with which to form that part, and a sweep to form the upper side.

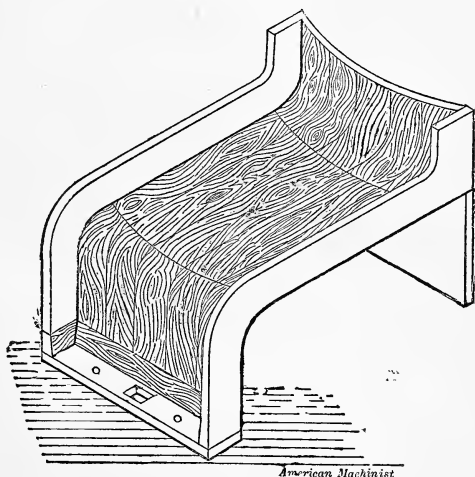


Fig. 207,

The core-irons for all such cores, of any magnitude, are best made as shown at Fig. 208. The manner of making such an iron is to have a pattern made the exact form of the core-print, but somewhat smaller, and about three fourths of the depth of core-print; a correct impression of this print is formed in the sand bed, and into it are cast holes for vents, staples for bolting into place, and wrought-irons, previously bent to form of core-box, of the requisite strength to form a strong core, these irons being further stiffened by securing cross-irons with tie wire, as shown.

When this core is made, have the vents set after the manner shown at Fig. 209, which figure represents the core as cut off at the top vents to show their correct position, also to explain the manner of connecting the vent after the core has been dried.

When the core is made, the vent-rods pierce the core and meet at *A*; when dry, a gutter is cut from *B* to *C* and the

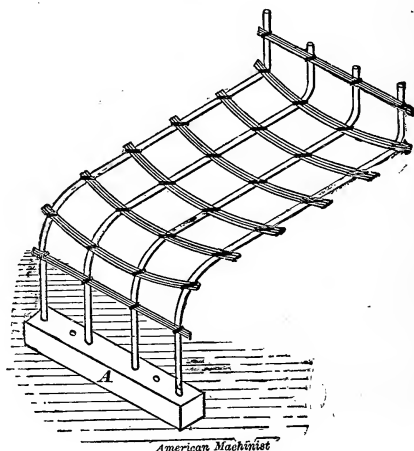


Fig. 208.

rope passed in at *D*; the gutter is then filled up safely and the rope withdrawn, leaving a clean vent-hole midway along the whole length of the core.

The above-described method of venting is much safer than to attempt the drawing of ropes through the core whilst it is green.

It is needless for me to say that the above is the very best way to make a port core, and when once adopted the system soon finds its way to other cores of different shape, for it must be admitted to be the acme of simplicity.

By referring to Fig. 210 it will be seen that in no sense



could the above-described method be improved on, even in the exhaust core for this job, and again at Fig. 211, where the block-print is again shown as used for an exhaust core,

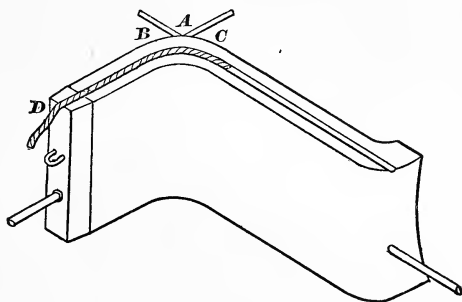


Fig. 209.

which, coming out higher up in the mould, requires a more elaborate core-iron than the one in question; such core-iron being simply two grates cast into the block-print *A*,

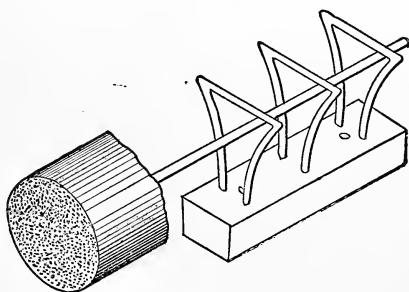


Fig. 210.

packed between and bolted together. Figs. 212 and 213 show sections at print ends, and Fig. 214 is section at *B*.

Two very important features in work of this class are

securing cores in their respective positions, and leading off the vents. By the adoption of the block-print absolute safety is assured as to the former, and the latter is made equally as safe by using pipes as leaders. It will be readily seen how one thing helps the other in this case; for, on account of the vent-hole being in the solid iron, the pipes may be ground in to fit the hole, or tapped, as may be thought best. With such a rig as this there need be no fear

Fig. 214.

Fig. 211.

Fig. 213.

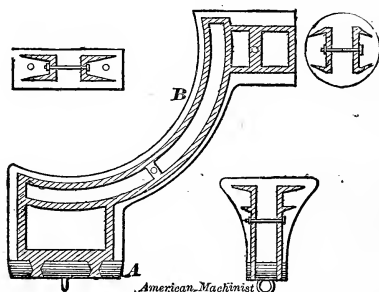


Fig. 212.

of doing damage when the spaces *MM*, Fig. 197, are being packed with sand after the whole mould has been up-ended, which operation needs to be done to prevent leakage at those parts.

If the principles laid down in the foregoing be strictly followed there will be no difficulty in doing away with the use of paste or any other damp preparation. I would advise moulders to avoid all such objectionable helps, as they not only soften the mould and cores, but also create steam, which is something not to be desired if good sound work is looked for; if it is deemed *necessary* to use a stopping at any critical point, let it be putty, which contains less moisture,

If cast studs and chaplets are used for this class of work, be sure that they are new, or at least perfectly free from rust, and if wrought-iron is used it is best to have the stock well ground before they are made, in order that the same shall be free from scale and rust; the mere operation of heating studs before using them is not always sufficient to destroy the accumulations of rust upon them, and if such studs are used and the heat be sufficient to decompose the rust upon them when the mould is poured, the disengaged gases will give trouble either by causing blown places in the casting, or, if enough gas be generated, by blowing up the job.

If studs are to lay long in the mould with any possibility of dampness reaching them, it is well to paint them, whilst warm, with a good coat of turpentine mixed with red-lead; this will prevent the rust from forming on them.

If a mould or core is damaged by being chipped or broken, do not attempt to repair such places with new material. It is much better practice to pound some of the same material similarly baked, and moisten with very thin clay-water; this will adhere more readily than the new, there being less shrinkage in it.

It will be found best, when practicable, to set all port cores back from the body core as much, at least, as will allow of the fin being easily broken through after the cylinder has been bored; this allows any accumulations of fine dirt to pass upwards through the space, leaving it cleaner at that point by just as much as passed through the aperture.

## JACKET-CORES FOR MOULDING STEAM-CYLINDERS.

THE subject of jacket-cores is a very important one, and demands our attention for a time.

It is true that in many places they have so arranged matters as to make a very simple job out of what was once a very critical one.

I think the most critical jackets to deal with in dry-sand work are those which allow of no other communication with the outside than can be obtained by about four round holes of the same diameter as the thickness of the jacket-

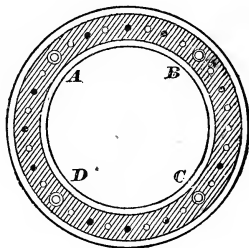


Fig. 215.

core, which in this instance we will suppose to be  $2\frac{1}{2}$  inches. These outlets, four in number, are equally divided at one end. Nearly all small cylinders of this class are made in loam, it being by many considered to be the only safe way to make them.

I claim, however, that such a job can be made absolutely safe in dry sand, if the plan of making herein suggested be adopted.

Fig. 215 is the plan, and Fig. 216 is a sectional elevation

of the jacket-core ; *A*, *B*, *C*, and *D* in plan represent the position of the four holes spoken of, through which all the gas generated in the core must pass, as they are also the only ones through which to withdraw the same after it is cast.

It will be seen that the core-iron is simply a cage com-

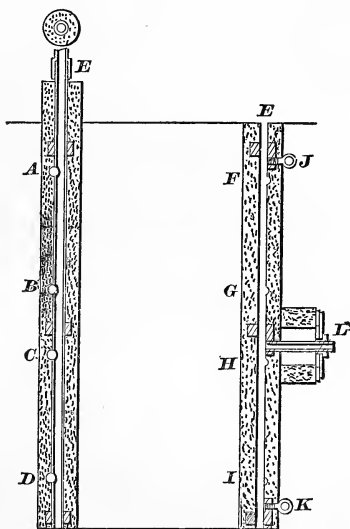


Fig. 216.

posed of three rings, as shown by shaded portion in plan, into which are cast the rods, cast or wrought, represented by black circles in plan ; at *A*, *B*, *C*, and *D* pipes are substituted for the solid rods, through which all the gas will pass, preparation for that object being made by filing holes at intervals along the pipes, as shown at *A*, *B*, *C* and *D*, Fig. 216. The white circles on the plan represent holes cast alternately with the irons and pipes, through which vent-rods are passed when the core is made.

To cast this cage, make middle ring, and thrust irons and pipes down into the soft bed the requisite depth, then cast and lift the whole into the second ring plumb and to the correct depth ; another similar operation for the opposite end, and the cage is made.

The four pipes must be long enough to stand through the core, as shown at *E*, Fig. 216, so that, when the jacket-core has been made, the cores may be slipped on and made secure.

To make such a core, strike up a dummy with bricks

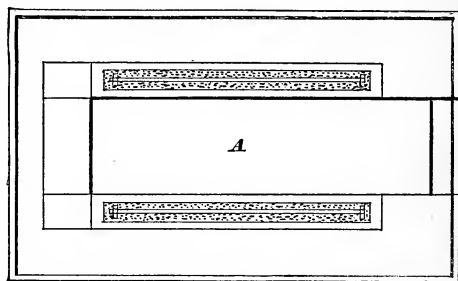


Fig. 217.

and mud, as loosely built as possible, and after thoroughly drying said dummy, and preparing for separating easily, place over and around it the cage, set in the vent-rods all round, and strike up the whole in loam of a good open nature.

When this core has been dried the dummy may be dug out, and the vents connected after this manner. File out a gutter opposite each of the holes indicated at *A*, *B*, *C*, and *D* in the pipes, and at the same time cutting into the vertical vents *E*, as seen at *F*, *G*, *H*, and *I* ; into this gutter a greased rope must be set, and the gutter made good over it, the rope being drawn along as piece after piece of the break is mended.



job at Fig. 220. It will be seen at *B*, Fig. 218, that, instead of parting the mould at this end in the usual way, I have carried the pattern, block fashion, as far past the end, and full size of pattern, as will give sufficient bearing for the body-core, making the parting over the top, and leaving a good body of sand between the end of pattern and flask, as seen at *C*, Fig. 218.

Fig. 221 will explain the way in which the cores are arranged that fill the block, and at the same time surround the four vent-cores of the jacket as well as the body-core, it being the end elevation of all the section cores, as they

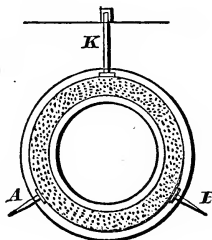


Fig. 219.

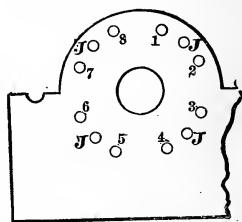


Fig. 220.

appear at line *D*, Fig. 218; the staples also are shown, by which the several sections are secured by hook-bolts—shown at Fig. 218—which pass through the holes marked 1, 2, 3, 4, 5, 6, 7, 8, Fig. 220, and are there made fast to cross-bars, the remaining four holes being those prepared for the vent-pipes.

After section *E*, Fig. 221, has been placed in position, as seen at *E*, Fig. 218, the jacket-core is set, and sections *F* and *F* put in, as seen at *F*, Fig. 218. This disposes of the two lower holes, and brings us up to the middle of the joint, as well as forms the seating for the body-core, which is now inserted by entering it at the opposite end, that end having been made an open one for the purpose; sections *G* and *G*



are now added, as seen at *G*, Fig. 218, and the whole capped with section *H*, shown again at *H*, Fig. 218.

A careful inspection at *E*, Fig. 216, will show how easy it will be, in this case, to make the outlet for the vent secure. All that is needed is to have the ends of the pipes threaded, on which can be screwed connections which will reach through the end at holes *J*, *J*, *J*, and *J*, midway between the figured holes, as seen at Fig. 220, also at *J* and *J*, Fig. 218. These holes must be made large enough to permit of sand being rammed round the pipe, thus making the whole job a very safe one.

The system of studding adopted in this example will

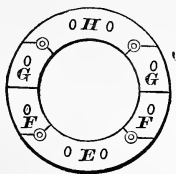


Fig. 221.

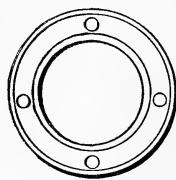


Fig. 222.

show how the moulder may control every chaplet and stud used in the job, and by so doing leave nothing to chance.

It is best to have top studs secured after the plan shown at *K* and *K*, Fig. 218, and again at Fig. 219, clamps being either cast in or bolted to the cross-bars for the purpose ; the end studs, shown in plan at Fig. 222, can be secured thus: Let bottom studs *L* and *L*, Fig. 218, be set back until the jacket-core is placed ; they can then be brought forward and wedged behind ; those at *M* and *M* being at the joint, can be readily adjusted, as also can the one at *N* ; the one shown at *O* can be set back so as to clear the jacket-core when the cope is lowered over, when it can be pushed forward and wedged, as shown, provision being made for this by leaving a hand-hole at the point *P*.

Another class of jackets are such as connect the outer with the inner shell by a series of ribs lengthwise with the cylinder, allowing for as many separate cores as there are ribs in the casting.

Usually a small hole is allowed on the bottom of each core, with a somewhat larger one at the top, and this one can be utilized for carrying off the gas.

Of course these cores must all have their own vent ; but as this can be done by passing a wire or wires from one end to the other, these cores are not very difficult to manage.

It is not a very difficult job to make such cylinders in

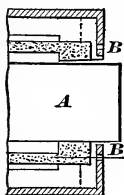


Fig. 223.

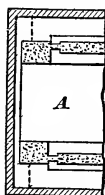


Fig. 224.

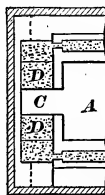


Fig. 225.

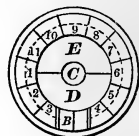


Fig. 226.

dry sand. Fig. 226 shows sectional elevation of mould, looking at the end ; Figs. 223, 224, and 225 show plans of the bottom half of mould and cores in section ; Figs. 223 and 224 show the arrangement of all the cores, when the bore is straight through. *A* in all the figures represents the body-core as resting on the jacket-cores marked 1, 2, 3, 4, 5, and 6 in plan, Fig. 226, equally divided on each side of port-cores, indicated by broken lines at *B*.

When the body-core has been set, all that remains to be done is to set the cores 7, 8, 9, 10, and 11, Fig. 226, and proceed to close over the upper half of mould.

It is important that all these cores should be the very best that can be produced, every precaution being taken to use none but what are perfectly sound ; the best core-iron for such a core is the one shown in section at Fig. 227, *A*

being section of core proper, exposing vents, and *B* representing the addition at the ends with gate or runner *C*. Fig. 228 shows the form of the iron as it lays in the core-box, and it is plain that with such an iron there can be no difficulty in making a reliable core.

Fig. 225 shows section of bottom half of mould with the cores all set, when there is to be an internal flange cast on the cylinder, as shown in figure.

The reduction of diameter of core, as shown at *C*, Figs. 225 and 226, necessitates the use of two half-cores to fill the space, as shown at *D, D*, with body-core resting in bottom half.

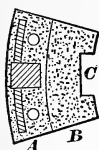


Fig. 227.

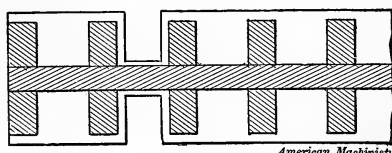


Fig. 228.

*American Machinist*

By again referring to Fig. 226 it will be seen that, when body-core *C* has been set upon block-core *D*, all that remains to be done is to secure the other half of block-core *E* in position, and proceed as before directed.

In making flasks for this job, prepare for taking the gas out at the upper end of jacket-cores, by casting holes in the box end, through which to pass the vent-pipes, as shown at *B* and *B*, Fig. 223 ; also, in arranging the cope bars, let the end ones in each case be placed so that the end spaces may be left unrammed, exposing about one third of the print end of the jacket-cores, as represented by broken lines in Figs. 223, 224, and 225. This will enable you to make the whole arrangement of jacket-cores absolutely safe, by ramming in sand at the ends after the cope is closed.

MOULDING GUNS, HYDRAULIC CYLINDERS,  
ETC.

WHEN hydraulic cylinders, rams, shafting, pipes, guns, etc., become so ponderous and unwieldy as to make it impracticable to mould them in top and bottom flasks, recourse is usually had to the method of casings, made to the form of the job for which they are intended, these being prepared for casting either by ramming sand in them—using a pattern to be drawn out endwise—or by “striking” on the inner surface a thickness of loam, using a spindle and sweep for that purpose.

As the latter method comes under the head of “loam moulding,” we shall pass it over and consider only such as are made in dry sand; and as one good example taken in detail will serve to bring out most if not all of the principles involved in the production of this class of work, we will take for such an example a Rodman gun, about 16 inches bore and 16 feet long, exclusive of sinking head, which we will suppose to be about 3 feet long.

To effect an equal cooling of the whole mass, when cast, a stream of cold water is introduced into the barrel, through the top at *A*, Fig. 229, passing downwards to near the bottom of the core-barrel through a pipe inserted for the purpose, and again rising up, filling the space between the pipe and the barrel; escaping at *B*.

The water is forced through at a pressure sufficient to enable it to carry off the heat as fast as it escapes from the casting, thus enabling those in charge to regulate the cooling of the gun, so as to preserve an even grain throughout the mass, with comparative freedom from fracture,—something it is next to impossible to do by any other known method.

Fuller details of the device for introducing the water into the barrel are shown at Fig. 230.

Fig. 229 is a sectional elevation of the whole mould and flasks, as it stands in the pit ready to receive the molten

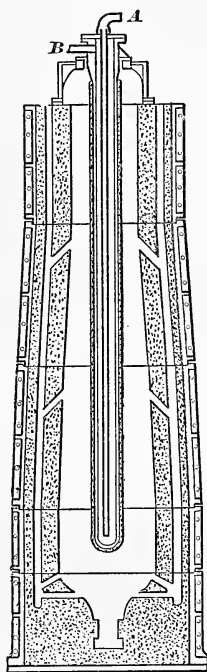


Fig. 229.

iron ; by referring to enlarged plan of same, Fig. 231, it will be seen that the section is taken at the points *A* and *A*, thus revealing the position of the running gates, the lowest of which must be set to give a rotary motion to the molten iron.

If these bottom gates are made large enough, sufficient

force will be given by them to keep the iron revolving round the core until it has passed the trunnions, and by this means preventing the dirt from finding a lodgment there; the upper gates augment the speed of the pouring, which perceptibly slackens as the mould fills, and also serve the purpose of keeping the iron in good condition at the top all through the cast—something very desirable when we remember how clean such a casting must be.

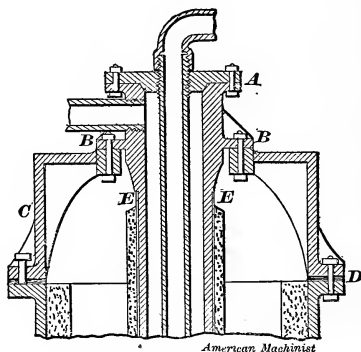


Fig. 230.

Fig. 232 shows full-length section of mould at the trunnion side, and also aids the reader in arriving at a full knowledge of the whole set of flasks or casings used.

As shown at Fig. 232, and again in plan at Fig. 231, the handling of these flasks is accomplished by slings which are made to fit the swivels seen.

That section which contains the trunnion calls for special mention, inasmuch as the trunnion pierces the casing, which is there strengthened by forming a circular box or pocket with an outer flange; this, of course, must be cast in one piece with the casing for that section.

This pocket must be true to position, with a slight taper

to receive the trunnion core when the casing is rammed; over this a strong plate with swivel attached is bolted. This, as will readily be observed, allows of this section being handled in the same manner as the rest.

No one without some knowledge of pressures and the strength of materials should attempt to prepare the apparatus needed for the construction of a job like this with-

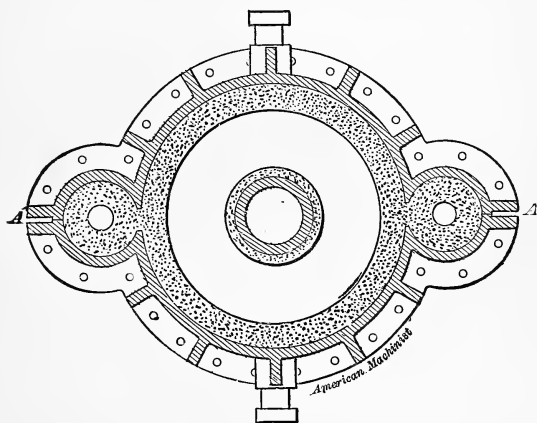


Fig. 231.

out first consulting some one acquainted with such subjects. Disasters are happening every day on this account, and men ought to learn from bitter experience the necessity for more knowledge upon matters so important.

These flasks should be  $1\frac{1}{2}$  inches thick at the bottom and 1 inch thick at the top, with flanges and ribs corresponding to thickness of sides, and all flanges should be wide enough to allow of 1 inch of iron outside the bolt-holes.

As shown, these casings are made in halves, parting at *AA*, Fig. 231. When made they must be bolted firmly together and turned at the ends so that they will not only

fit each other true, but will also fit the face-plate shown at *AA*, Fig. 233.

This plate is turned and prepared as shown, for the purpose of receiving the pattern, flask, and gate-pins of all the sections.

Fig. 233 is intended to explain the manner of changing

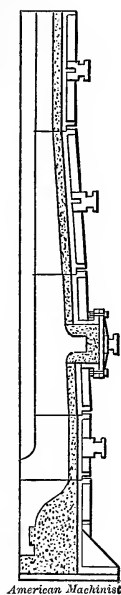


Fig. 232.

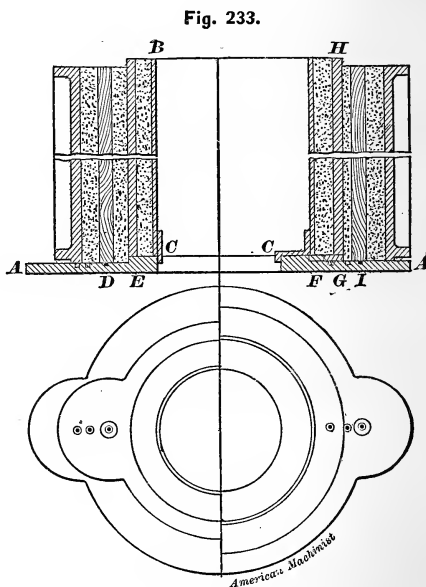


Fig. 234.

for each section; the reader will be helped very much by observing the plan view of the same at Fig. 234; on the left hand of Fig. 233 it will be seen that the pattern is set for the smallest or "head section." These patterns are cast-iron, turned to size, and fitted with bottom guides to fit face-plate, as seen at *C*, which is turned to receive the same.



This being the smallest piece, the gate-pin is guided by the inside hole at *D*, and the flask is held in position by the shoulder at *E*.

To form the moulds in the other flasks on the same face-plate and with equal facility and correctness, rings *F* and *G*—also turned to fit—are set on respectively, and the operation duplicated.

The right-hand view shows these rings in position, and the flask for the breech set thereon and rammed; this, of course, is the largest in diameter; flask *H* is seen over the

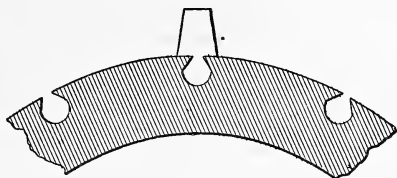


Fig. 235.

edge of the outer ring, the gate-pin *I* occupying the outer hole.

The bottom section of this mould may be rammed over a face-board and pattern, or struck with spindle and sweep, or any other suitable guide-way.

A set of casings, got up after the design just explained, eradicates all the difficulties in obtaining a true mould, as moulds having a vertical height of thirty-five feet may be made in them, with comparatively no deviation from a straight line.

The barrel for this core should be not less than one inch thick, and for obvious reasons must be perfectly sound, with grooves at intervals around the circumference; the expense of cutting these grooves may be saved if, when the barrel is made, prints be set on the pattern into which cores may be inserted along its length. Fig. 235 will give

some idea of what is meant; the form of groove shown is the least likely to damage the barrel from shrinkage.

These barrels should have at least  $\frac{3}{4}$ -inch taper in their entire length.

There is naturally more handling of such a core as this

Fig. 236.

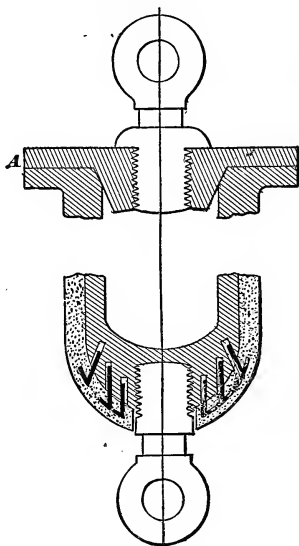


Fig. 237.

than is ordinarily the case, and, in order to facilitate this extra usage, I have shown at Figs. 236 and 237 the necessary preparations.

At *A*, Fig. 230, the gland is shown which holds the down pipe in position as well as serving to make good the joints at the top. During the process of making the core we substitute the plate *A*, Fig. 236, for the one shown at *A*, Fig. 230, bolting it to the barrel after the manner shown at

Fig. 230, and for the opposite end a tapped hole is prepared, into which a threaded gudgeon is screwed, as shown at Fig. 237.

The eyes serve to lift by, and the turned shoulders give a true motion to the barrel as it revolves on its bearings, thus insuring a true core.

It will be seen at Fig. 237 that holes are cast into which irons can be wedged and bent to the form of the core at the lower end; this is better than attempting to carry the

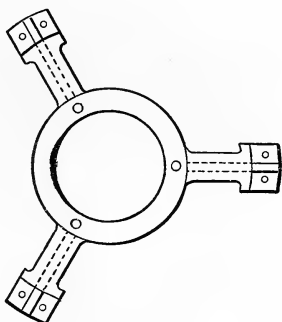


Fig. 238.

loam at this point with prickers, which are almost certain to be broken off the first time it is used.

The gudgeon at the lower end serves another good purpose, namely, that when it is desired to raise the core on end, previous to lowering it into the mould, the whole weight of the core may be sustained by it during the operation, keeping the core clear from all likelihood of damage, as well as facilitating the operation in a very great measure.

When the core has been suspended the bottom gudgeon can be taken out and the hole plugged.

The bracketed lugs, cast on the core-barrel, and seen at *BB*, Fig. 230, serve a double purpose in this case. As may

be observed, these lugs rest on the tripod *C*, at that point over the holes shown at plan of same at Fig. 238. This tripod must be of sufficient strength not only to sustain the weight of the core, but also to resist the pressure under the same when the mould is filled, which is far greater than its own weight, as may be ascertained by consulting article "Pressures in Moulds."

To accomplish this the barrel is secured to the tripod by

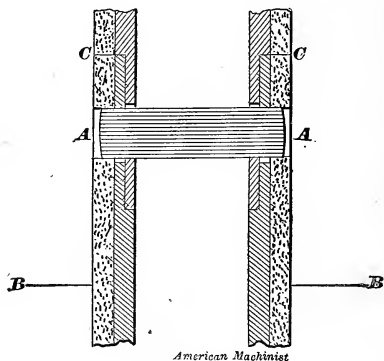


Fig. 239.

bolts, as shown at *BB*, and the tripod made fast to the top flange of casing, as seen at *D*, Fig. 230.

I have purposely shown the leg on the left out of position, so that the whole arrangement for setting this core might be shown.

It will be seen at plan, Fig. 238, that there are two holes on the ends of each leg; one of these is to bolt down with, as at *D*, Fig. 230, and the other, being a tapped hole, is to be used for raising or lowering the core when it is being set in position.

The terminations of the grooves in the barrel are shown at *EE*, Fig. 230, about twelve inches higher than the top of the casting.

Whatever soft material is used for wrapping the barrel before rubbing on the loam, be sure and use no more than will barely cover the grooves, and thus keep out the loam; for if too much of hemp, hemp rope, or hay is used, the pressure around the core will crush in the loam, the thickness of which in this instance should not be less than  $1\frac{1}{2}$  inches.

Some cores for hydraulic cylinders may be required as long as thirty feet. These must of necessity be made in two lengths, and this can be accomplished very readily by adopting the method shown at Fig. 239, which is a sectional view of the junction of the two core-barrels.

The barrels must be made thick enough to allow of one being bored out about 18 inches deep to half its thickness at that point, and the other turned to a snug fit in the same, as shown; a keyway must be prepared to admit a tapered key, which, when driven home, will be equidistant from each side of the core, the spaces at the back *AA*, as well as the seam *C*, being afterwards made good.

To close such a mould with the core made as above described, let the casings be set upon each other until as many are down as will allow the first core to stand one foot above the joint of the upper casing, indicated by lines *BB*; the upper length of core can then be set as previously explained, and the remaining flasks closed over.

In bringing these articles to a close, I would say that it has been my earnest endeavor to introduce such jobs as would bring into operation methods which may be made of almost universal application; and whilst it would not appear that very many examples have been chosen, it will be seen, if a careful analysis is made of the whole, that such examples as were chosen embrace more of the every-

day difficulties which beset the moulder than could possibly be found in the same number of any other kind or quality.

It would, I know, have been easier to have selected a larger number, but the description of the methods for moulding them would have been a mere repetition, and that I have endeavored to avoid.

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## TO MOULD CYLINDRICAL WORK IN TOP AND BOTTOM FLASKS WITH SPINDLE AND SWEEP.

WHEN a cylindrical casting is ordered, for which there is no pattern of the required diameter, the ordinary method is to make the job in loam, if practicable, or else lag up a pattern which is nearest to the diameter wanted; very often a new pattern is made at considerable cost, and never used afterwards.

All this annoyance and loss may be easily remedied by adopting the system which I propose to explain in this article. Furthermore, I am convinced from experience that very many castings may be made in top and bottom flasks with the spindle and sweep as good, and in as short a time, as from a pattern, thus saving the cost of pattern-making altogether in many instances.

Sugar-mill rolls, rolls for copper and iron, pipes, shafts, side-pipes, etc., are a few of the castings for which this method is eminently adapted, the only requisite for the successful accomplishment of which is a well-proportioned set of flasks suitably equipped.

For the purpose of thoroughly explaining such a set of flasks in detail, I have selected a roll 24 inches diameter, with 12-inch necks, to mould. I am thus enabled, by aid

of the several illustrations accompanying this article, to show more definitely than could otherwise be done what is needed in their design and construction. As will be seen, I have not attempted to fill in every detail, but have simply given a general outline of the whole, with just enough of detail to make the explanation easy.

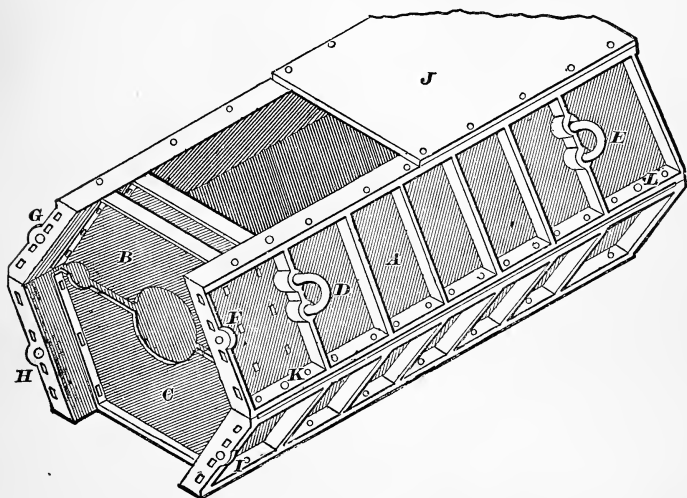


Fig. 240.

The best flask for moulding such work as rolls, pipes, etc., or any other plain cylindrical casting, is the one shown at Fig. 240. As seen, the sides are drawn over sufficiently to allow of about as much sand between the flask and the casting as there is on the back, which in this case is about 6 inches: the width at the joint must be determined by the amount of room needed for the upright runners. By referring to *B*, Fig. 241, the reader will see the position of such runner as arranged for filling the mould in preparation. A common error in making flasks for this

class of work is that they are not made proportionately strong at the outset, the result of which is that in a very short time they become dangerous, on account of their fractured condition, caused by the unequal expansion and contraction of the parts when in use. Let the sides of this flask be made of a uniform thickness of  $\frac{3}{4}$  inch, and have

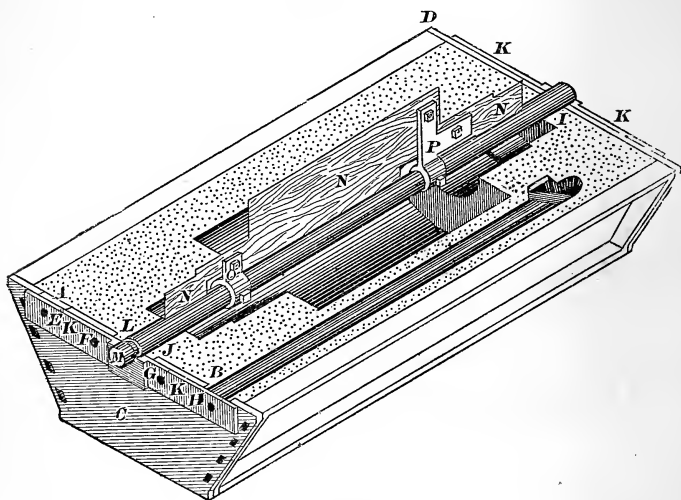


Fig. 241.

the webs which connect the flanges come flush, and from 12 to 15 inches apart, as seen at *A*, Fig. 240, and depend upon it you will not have much trouble from breaks if ordinary care is exercised in the handling.

When it is necessary to strengthen any part of a flask on account of extra duty imposed there, do not (if avoidable) try to accomplish it by adding thickness, but add webs or brackets to give the strength needed. You then attain your object without a sacrifice of proportion,



Fig. 240 is a view of four such sides as I have been describing, placed in position. The ends are purposely left off, so that a view of the inside, showing the position of the bars *B* and *C*, can be obtained. Although the handles for lifting purposes are only shown at *D* and *E*, it is supposed that all the sides will have them. They are of wrought-iron, and need not stand out further than is required to pass the chain through for lifting and rolling over. When, as in this case, it is necessary to cast in a vertical position, the lugs *F*, *G*, *H*, *I* are used for raising the mould on end and lifting into the pit. Be sure that these lugs are well secured to the side by brackets cast on each side of the holes. The thickness between the brackets can be increased to  $1\frac{1}{2}$  inches, on account of the extra wear and tear of that particular spot. At *J* is seen one of the plates which must be bolted along the back of the flasks when the bars are untrustworthy, or when the mould is so large as to make their use absolutely necessary. But with 6-inch spaces between the bars, and 6 inches of sand from the mould to the back, the using of plates is superfluous, provided the bars are made as shown at *B*, *C*, with the flange for bolting to the sides continued across the back, the mould well rammed, and thoroughly dried. These remarks apply only to such moulds as we have under consideration, being not more than ten feet from top of pouring-basin to base of mould.

Another common mistake in making these flask sides is to fill them with holes other than the ones required for securing to the cross-bars: these are a source of weakness, and should be avoided. If the holes for bolting the bars be made longer than their width, as shown, there will be sufficient opportunity given for the escape of steam and gas. I would here say, that although I have shown all the slot holes in these views to have square corners, I favor the idea of rounding them at the ends, as they do not weaken

the casting so much. Let the flange along the joint be set back so as to leave about  $\frac{1}{2}$  inch space when they come together, into which mud can be packed to prevent leakage when the mould is poured. I have shown this space in Fig. 240; it will also be observed that all the bolt-holes for binding the two parts together are in close proximity to the webs. This, of course, obviates the danger of pulling away the flange when the flasks are being screwed together. It will also be seen that the bars *B* and *C* are shown solid all through. The remarks on superfluous holes in the sides apply in this case as well; the fewer the holes the longer will be the life of the bar, and the whole thing will be benefited thereby. I deem it well to state that all box-sides, for purposes such as we have been describing, should be cast under pressure; this gives them greater strength, and they are easier to handle and fit together.

By referring to Fig. 241, it will be seen what kind of ends are required for such a job. This view gives an outline of as much of one half of the flask as is necessary to explain the method of rigging the ends. *C* is the upper end, and, like the lower one, *D*, must in this case be made not less than  $1\frac{1}{2}$  inches thick. In addition to the holes for securing to the sides, as seen at *C*, there must be holes cast to correspond with those marked *E*, *F*, *G*, *H*, to be explained further on. The end *D* is plain along its upper surface, excepting a half hole at the centre, to allow of the spindle passing through at *I*, but in end *C* provision must be made for the runners, as seen at *A* and *B*, and also for the feeding-head at *J*.

The arrangement for the spindle is simple: four fixings are made, similar to the one shown at *K*, the inside edges must be planed true, placed together in pairs, and bored, one to take the body of the spindle, the other a little smaller; this permits of a little being turned off at one end of the spindle to shoulder on both sides of the fixing,

and serves to prevent the spindle moving endwise, as shown at *L*. This fixing not only serves as a bearing for the spindle, but, as will be seen, forms the joint also. When one has been bolted at each end of one of the flasks, as seen at *K*, Fig. 241, place in the spindle and set on the other flask, pinning it in the usual manner. *K* and *L*, Fig. 240, show two of the pin-holes, and similar ones are supposed to be on the opposite side. The other fixings can now be brought over the spindle and bolted to the upper flask, taking care to have a close fit, with no possibility of their shifting during the operation of sweeping the mould.

Fig. 241 is a representation of the apparatus for sweeping the mould. The spindle *M* is resting on the bearings *K*,



Fig. 242.



Fig. 243.

and the sweep *N* secured to arms *O* and *P* stands vertical to the swept mould. The surface of the joint is made to the planed edge of the end fixing by using a straight-edge which rests on both ends, and must therefore be as accurate as the bearings themselves.

I have shown the runner for this roll extending along its length to the lower neck, at which place it is best to run these castings after the manner shown in section at Fig. 242. *B*, Fig. 242, is that half of upright seen in Fig. 241, and connects with gate *C*, so placed that the fluid iron, on entering the mould, shall strike the outer surface. This gives it the course indicated by the arrows, and of course imparts a rapid circular motion to the iron which drives the scum and dirt to the centre, to be discharged into the feeding-head when the mould has filled.

To prepare these moulds, begin by ramming the flask full of good ordinary floor-sand, not over damp; strike off the joint about  $\frac{1}{8}$  inch below the fixings at the ends; mark off the mould to the sweep, and then cut out the sand about  $\frac{1}{2}$  inch clear of the sweep all over; then moisten the surface with thin clay-water. It is now ready to be swept, and whatever has proved itself a good dry-sand facing for heavy work will make a good loam for this purpose, by adding water sufficient to bring it to the right consistency for working easily. Let a little, which has been made extra thin, be rubbed well over the surface before the loam is applied; this helps it to adhere to the sand.

Whilst this is stiffening go through the same process with the other half, by which time the first will be hard enough to receive the finishing coat, which need not be any other than a little of the same loam thinned down with water and put through a fine riddle or sieve. For roughing it will be found best to push the sharp edge, and in finishing the chamfered edge, through the loam; and should it be required to duplicate a job often, it is advisable to bind the edge of the sweep with hoop-iron.

When the mould has been swept, the joint can be finished off with the straight-edge, the  $\frac{1}{8}$ -inch clearance allowing of just so much thin loam being struck on at that part. This gives a good even surface, much superior to anything got by sleeking with the trowel.

I might here observe, that where much of this work is done, a half runner of the required size could be made and bedded in the sand when the flask is being rammed; the same in regard to wobblers, etc., as shown at Fig. 243. One half of these can be made to fit the spindle, and rammed into position before the sweeping takes place. For the benefit of such as have not had any experience in mixing blacking for such jobs, the mixture given below will be found useful:

To 1 of best mineral, add  $\frac{1}{2}$  good heavy charcoal,  $\frac{1}{4}$  of XX silver lead,  $\frac{1}{4}$  of hard Lehigh blacking. Mix to the right consistency with clay water, just thick enough to color the hand.

Whether the mould is blackened wet or dry, there should be about  $\frac{1}{16}$  inch of this blackening brushed or swabbed

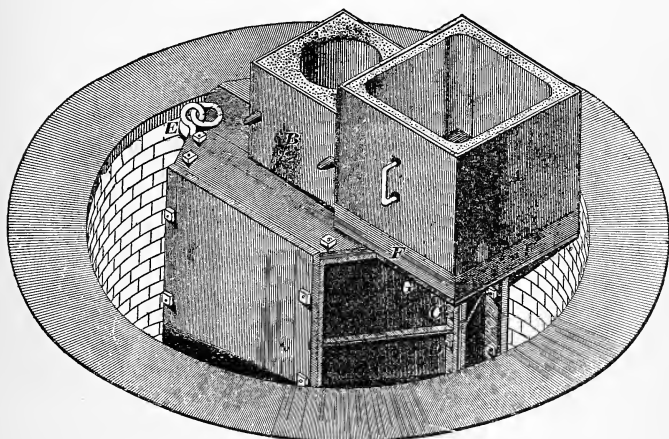


Fig. 244.

all over it; but it is by far the best to blacken the mould while green.

I shall not waste time and space to prove the necessity of thoroughly drying all moulds, especially of pieces that are to be bored or turned, for it must be plain to the most ignorant that the freer a mould is from steam, the greater is the chance of securing a sound casting.

I do not consider rolls to be in any sense an exception to this rule; therefore, however urgent may be the demand, I deem it an injustice to the founder to expect a sound casting if time is not allowed for drying the mould before it is poured.

Fig. 244 is a view of this mould resting on end in the pit. The runner-box *A* and feeding-head *B* are shown in position. The pit has a 12-inch wall built around it, capped by a cast-iron ring two inches thick. After the two parts are placed together, and secured by bolts, as seen at *C* and *D*, ring-bolts like the one shown at *E* are secured in the four end lugs, a short strong chain for the purpose can be hitched to the bottom rings, and the mould raised on end; all four can now be used, and the whole lifted clear and lowered into place in the pit.

Fig. 245 is a sectional elevation of the feeding-head resting on the box; it is seen to increase in diameter until it is

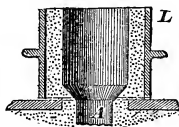


Fig. 245.

about the same size as the neck, and 12 or 15 inches deep. This needs to be done so as to have a supply of liquid iron above, to follow up the shrinkage which takes place in the mould immediately after it is cast.

It is wise in some instances, as when the iron is unreliable, or the feeding-head necessarily small at *A*, to use a feeding-rod, pushing it through the head and down into the body of the roll; this keeps open the communication with the supply above, and thus prevents a drawn spot at the junction of the neck with the body. The running-head as well as the feeding-head are best made in dry sand; it adds materially to their safety, besides being cleaner.

To prepare this runner, have a plate, *G*, made to clip the outside of the flask and the form of the runner-box; with wrought pins cast in to correspond with end holes, so that after the ring-bolts are taken out the holes will serve

to secure the plate to the flask. The frame marked *F* is now placed on the plate *G*, and the runner raised to the level of the frame by a core made for the purpose. When this has been rammed and swept off, it is ready to receive the running-head, which, having been rammed on a true surface, is readily rubbed down into place. Should there be no mould into which the spare iron can be poured, it is best to prepare a channel from the feeding-head to a good-sized pig in the floor, and run the whole of the iron through the mould. It is well, also, to keep the runner as much higher than the feeder as will allow of most of the iron escaping from it through the feeder, as described, as it carries away the sullage and cold iron, and leaves a good supply of clean iron to follow up the shrinkage.

The general principles laid down in this description for making a roll will serve, with some slight modifications, for anything else of a like nature, and any of the ordinary top and bottom flasks can be converted into a spindle-flask by having the ends made to suit.

Flange-pipes can be swept very readily; brackets, nozzles, etc., can be easily attached by a system of block cores to be set to the sweep when the box is being rammed. Nor is this system confined to dry-sand castings; for with a little practice as good green-sand work may be accomplished this way as from the pattern.

## PART V.

### *GREEN-SAND MOULDING.*

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#### PULLEYS, AND HOW TO MAKE THEM.

WHEN a firm contemplates making a new set of pulley patterns it is very essential that more than one system be considered. But very often such is not the case, the whole set, from the largest to the smallest, being made after the same model, only to be repented of after the expense has been incurred of making patterns which are not by any means the best for the purpose. It is also very interesting to observe how various are the methods of moulding from the same pattern, as I shall show further on.

If I should enter a foundry and see a man preparing to lift the upper half of the inside of a 6-foot pulley, 12 inches deep, with gaggers and cheeks, and was informed that the pattern from which he was moulding was a straight rim with loose arms, and that this was their regular system of making such a pulley, I should at once conclude that it would be best for that firm to buy all their pulleys from the specialist, and the sooner they began to do so the better.

As before stated, there are many kinds of patterns. For example, we have the straight rim with loose arms;—an excellent plan, because of the facility with which rims of any width desired can be made from them, by simply setting the arms in position to be central after the rim has been



drawn to the width required. A sectional view of such a pattern is shown at Fig. 246.

Then, again, we have the pattern with the arms either cast to the rim or secured to it after it has been turned true on both faces, and good draught allowed on the inside (Fig. 247); also those made in halves, as shown at Fig. 248.

Fig. 249 shows another form, being simply the top half of rim, loose from the body.

We have in these selections a goodly array to choose from, and whilst, in my opinion, the one shown at Fig. 246 is the

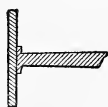


Fig. 246.

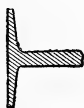


Fig. 247.

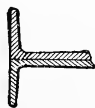


Fig. 248.

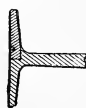


Fig. 249.

best for general purposes, we cannot afford to ostracize the rest, for, as I shall presently demonstrate, they all possess merits peculiar to them, which cannot be denied nor be dispensed with, if we would make the best of our opportunities.

Beginning in their order, as above described, we will proceed to analyze the several methods by which we can make pulleys from the loose arms and rim. Fig. 250 is a full view of such a pattern—6 feet diameter, 12 inches deep. The inside is rammed up to the joint of the arms, and the lifting-plates or arbor set down thereon. It will be seen that all these plates are bound together by clamps which are cast in when the arbor is made, as also are the three lifting-staples, *A*, *B*, and *C*. Unlike most arbors of this kind which I have seen, I choose to have the flat side of the plates down on the bed, as shown, because it is so much easier to make the joint. To make an arbor like this, place the arms on a true bed and mark off the clearance all

around. This impression will be taken on the cope, which must be rammed on the bed. After the cope is lifted off, as many feet or guide-pins as are requisite can be set in, the marks serving as a guide to place them. Be sure and make them large, so as to have good taper and plenty of length.

Fig. 251 shows a section of plate, with foot *A*. The pattern for the plates can now be bedded to the lines on the bottom, after which the clamps and staples can be sunk in

Fig. 250.

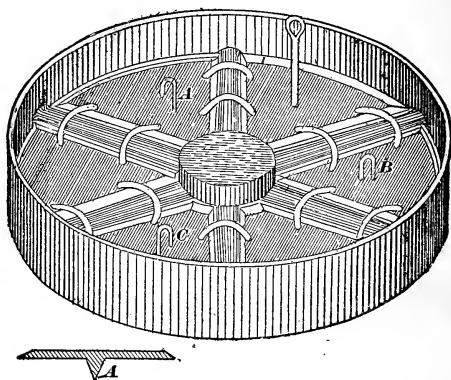


Fig. 251.

their places. Be careful to have the ends of the clamps clean and well jagged, to take a good grip of the iron, or they will soon jar loose. Another important item is to have the connecting clamps strong; otherwise it will soon be twisted out of shape. With such a rig as this, pulleys can be made very readily.

Of course, I am now speaking of such as have but one set of arms. When one with double arms is to be made, the bottom set of plates must be cast separate, on account of their withdrawal when the pulley is cast. If two sets of

arm patterns are supplied, cast nuts in the loose bottom-plates to correspond with holes in the arbor-plates, through which bolts can be inserted to bind the two sets of plates together, after the top set of arms has been taken out and that portion of the mould finished.

I incline to the opinion that no particular advantage accrues from the use of two sets of arms, for all that is needed to accomplish the job with one set is to cast three studs on the back of each of the bottom-plates long enough to give a sufficient body of sand over the arms. A staple

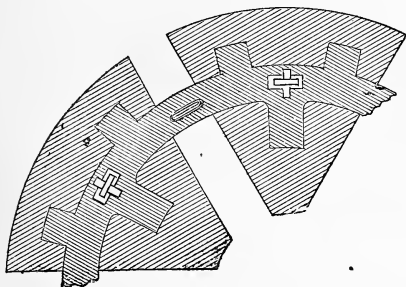


Fig. 252.

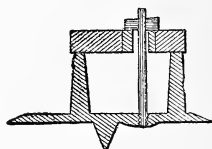


Fig. 253.

is also needed in the centre of the plate which is to pass through a spider made to rest on the studs. A key can then be driven home between the staple and spider, and all will be secure. I have shown this arrangement in plan and elevation at Figs. 252 and 253. It will be seen that the whole rig can be keyed together off the mould and used after the manner of the upper arbor. In this case the rim will have to be drawn out of the mould after the ramming has reached the height of the spider, and placed back again after the arms have been taken out, the mould finished, and the upper portion of mould set down in place. The

keys can now be knocked out, the spider lifted away, and the mould proceeded with in the usual manner.

Although the arbor just described is a good one, and has many admirers, yet all admit its liability to warp out of form, so that it would appear that there still remains room for improvement. Fig. 254 is the sketch of an arbor which can be used very readily for all sizes from 12 inches to 12 feet diameter. This arbor is perfectly rigid, and cannot possibly get out of order. A good way to make such an arbor

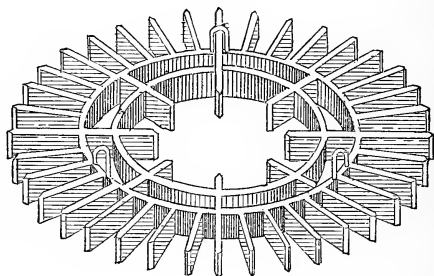
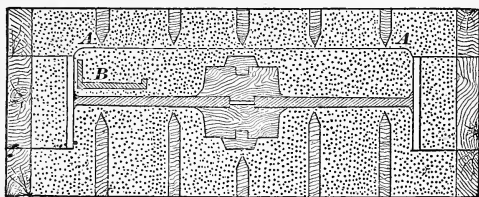


Fig. 254.

is to make a pattern of one half, quarter, sixth, or eighth, according to size of pulley. You then have the pattern by you ready for emergencies, whereas if they are made from rings and loose pieces the probability is that you will have a new rig to make every time. In making this arbor cut out to clear the arms (this allows of the iron coming down on the joint), and cast on good, stout feet, with plenty of taper, as directed for the plates.

Before quitting the subject of moulding from a loose arm and straight-rimmed pattern, I would call attention to an ingenious way of using it in sizes from 12 inches to 30 inches diameter. Let us suppose one 30 inches diameter and 8 inches face. The first operation is to place the rim

on a face-board and set in the arms (the best method of doing this is to have a block which will not only centre the arms, but will at the same time form the joint), have a three-part flask with cheek same depth as the rim, ram up the outside, joint, and then ram the cope. When this is rolled over and the inside block taken out, the inside must be rammed a little higher than the rim and a parting made all over. The nowel in this instance must be barred as a cope, to suit the form of parting. Let the nowel be rammed and lifted off; the rim is now to be drawn out and the nowel put back, and after securing the three parts



(Fig. 255.

together, roll all back again into position. The top part can now be lifted off, and there being no rim in the mould, a good lift is absolutely certain. Pulleys up to the size mentioned can be made very rapidly this way. By consulting Fig. 255 the reader will see the complete operation at a glance. The bottom cope or nowel has been replaced after the rim was taken out. The reason for making parting *A* with a rise is to help keep the core in place when it is rolled back. A few lifters laid in the core (as shown at *B*) on the bottom side will prevent any of the mould from falling away when it is being turned back.

At Fig. 256 I have shown a method of making pulleys from patterns which have the arms either cast with or secured to the rim. The lifting-plates in this case are used

separate, and must be made with a sharp edge to fit against the rim, in order to insure a good lift, as seen at *A*. The lifting-irons must be long enough to stand through the bars of cope, as at *B*, and the best way of connecting them with the plates is to have the hole in the plate a little smaller than the iron, so that a shoulder can be forged on, to prevent them slipping through. In riveting the button underneath, leave it slack, so that the iron can be turned easily in the hole. This allows of its being twisted round to clear the bars of the cope. Pulleys can be made very

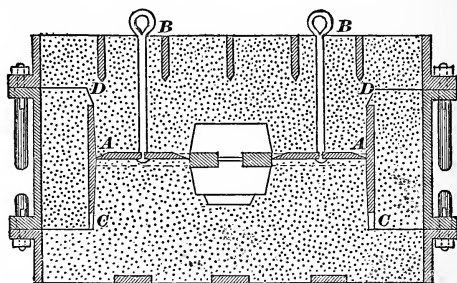


Fig. 256.

readily from these patterns when the flasks and lifting-plates are in good order. The handiest way of working them is to ram the inside first, make parting at arms, and bed down the plates, after which ram up to the top of the inside and loosen the pattern all round before the outside is rammed. After the cope is rammed the plates can be quickly secured to the cope by wedging under the irons put through the eyes of the lifting-irons. The figure shows an iron flask with long pins, but if wood flasks are used, a little extra care in fitting on good copes will be necessary.

The pattern shown in the flask is 30 inches diameter and 8 inches deep, but the casting required is to be 12 inches

deep. Now, as this is not a loose rim, another method must be adopted to deepen the rim and have the arms in the centre when cast. In order to do this one half of the difference must be added to the bottom and the other to the top. The way to do this is shown in the figure. The pattern has been drawn two inches from the bottom at *C*, and the outside parting made two inches above the pattern at *D*, where a little draught has been given to the joint to save dragging up the parting. When the cope has been lifted off the pattern must be placed on the top part of mould and a strickle passed round under the edge to scrape out the sand level with the inside. This will insure a perfectly even thickness all around, which could hardly be the case if the pattern was not used for a guide, as directed. If the flasks for this class of work are made after the manner shown in this figure it becomes an easy matter to part the mould at the bottom, and this enables the moulder to finish his work satisfactorily.

Pulley patterns which are standard and not more than two feet diameter, nor any deeper than six inches, are best made as shown at Figs. 248 and 249. I prefer the one at Fig. 248, for the reason that both halves are equally strong and less apt to get broken. Another advantage is that there is less trouble in parting the arms. If good headway is to be made with this class of pulleys, light iron flasks are indispensable.

#### PULLEY MOULDING FROM SWEEPS AND CORES.

Sometimes a pulley is ordered for which there is no pattern. When this occurs a very simple plan can be adopted to overcome the difficulty.

Let us suppose the pulley to be of the same dimensions as the one shown at Fig. 250, 6 feet diameter, 12 inches deep. Figs. 257, 258, and 259 will show the different stages of such a job with very little explanation.

After a suitable hole has been dug in the floor in which to mould the pulley, set in two straight-edges and strike off a true bed, in the centre of which ram up a good stout steady pin, after the manner shown at *A*, Fig. 257. (It is supposed there is no spindle or centre where this pulley is being made.) A plate, *B*, is now bedded down one inch below the surface, as at *C*, and the joint continued to the surface of mould as at *D*. Although this plate is shown well up to the centre, it really does not require to come any further than the point where the cores meet each other in the hub, thereby saving weight. The sur-

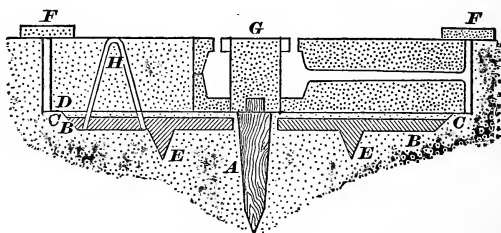


Fig. 257.

face over the plate is now to be swept off level with the outside and a line struck to the inside diameter of rim, to be divided into six, and each division to be drawn to the centre. Fig. 258 shows the cores made in halves joined together and set into position; it will be observed that these cores, when together, are the exact depth of the rim. All that is required now is to set sweep *A*, Fig. 258, and ram in between the cores; spaces *B*, *C*, and *D* are shown as filled in, and the sweep moved round to the next space. Before proceeding to ram in the spaces the cores can be clamped together as seen at *E*, Fig. 258, as many being used as are thought requisite; observe that provision is made for running in the hub, and that the end of cores form print for centre core. After this operation is complete hitch on to



the handles shown, and lift the whole thing out of the mould, taking care to steady it out of the feet shown at *E*, Fig. 257.

Just here I will explain why I lift out the inside. It is customary, in making pulleys from cores and sweeps, to have segment cores to make up the outside, setting them to line and ramming behind them after they are all in position, but I have yet to see the casting made after this manner that was true, or anything near it; therefore, I think that the little extra labor entailed in lifting out the

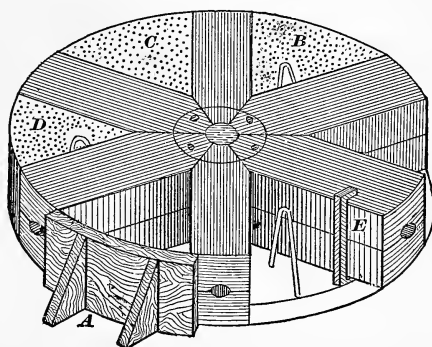


Fig. 258.

inside is more than compensated for if we gain a correct outside by the operation.

Fig. 259 is a view of the bed under the plate, with parting all round and the bottom surface on which the sweep rests. This sweep is the one used for the inside, with the braces reversed and continued to the centre-pin, which it is supposed to fit accurately. The view shows the sweep as having been started at *A* and the upper side rammed as far as *B*. I have shown the centre pin as standing up above the bed on which the lifting plate rested. It will be seen that in attaching the continuation of the braces, they

are shouldered together at *C*; this allows of their easy separation before the sweep is removed, if it should be thought desirable to do so; if the pulley was round on the face then it would be requisite to do so. To make a flange pulley by this method have a segment or flange for top and bottom, bed in the top as you go along, the bottom one to be set against the sweep and withdrawn each move that is made.

When the outside is rammed and finished it will take but

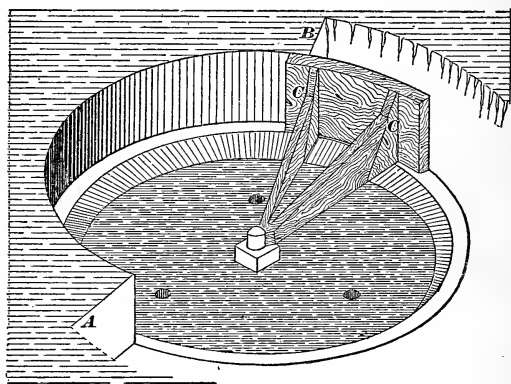


Fig. 259.

a short time to complete the job. After the centre has been taken out and the hole made good, place back the inside and cover the rim with cores, as shown at *F*, Fig. 257. The centre core is seen in place at *G*, Fig. 257; but it must be remembered that the plug *A* is supposed to be out when the plate goes back, otherwise this figure may be taken as a sectional elevation of the mould when closed, cut through the centre of arm-core on one side and through the space on the other, exposing handle *H*.

## TO SPLIT A PULLEY.

This is generally considered an unpleasant thing to do, but I think that a considerable amount of the annoyance is self-inflicted. Ordinarily too little care is taken in the preparation needed to insure success in splitting a pulley or wheel. Some of the methods adhered to have been handed down to us by our grandfathers, and we stupidly insist on their use, good or bad. Very often it occurs that a split pulley is wanted in a hurry, and along with the pattern comes the splitting-plates, cut out of plate iron perhaps not more than  $\frac{1}{16}$  inch thick. Suppose the pulley to be six

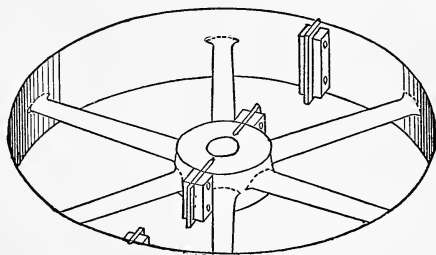


Fig. 260.

feet diameter, 12 inches deep, with a very heavy hub, such as shown at Fig. 260 (which is a sketch of the inside of pattern with splitting-lugs attached). In some foundries all that is considered necessary is to heat the plates and paint them with gas tar, but it invariably happens that when there is a considerable body of metal that the tar burns away, and the plates are fast in places on both sides, making it difficult to separate the halves; in fact, it is no uncommon occurrence to break the casting somewhere else in the effort used to split it. Such a method as this ought

to be abandoned at once. Again, at other places the splitting-plates are treated to a thin coat of fine loam, and if the loam could be kept on them the plan would not be without some merit. But when spikes are thrust down each side to secure them, it is barely possible to keep them in good trim. However much success may attend the use of plates prepared this way, they cannot in any case be used for packing when the pulley is bolted together, being slack the amount of loam used to cover them. Some think oil will do, and others maintain that a coat of blacking will answer the purpose; but I need not waste words to prove the inadequacy of such methods to insure a good job.

As before stated, Fig. 260 shows the inside of a pulley pattern with the splitting-lugs attached. The prints seen on the lugs are to receive the splitting-plates. Let patterns be made for these plates  $\frac{3}{8}$  inch thick, with front edge feathered. The feather edge must set into the rim a little, and as far back from the centre core as will permit of an easy split.

In moulding these plates use such sand as will allow the hot iron to eat into it, so that the skin of the metal will not be exposed; when cast, rub off the loose sand and spread a coat of very thin glue all over the surface, over which a little fine burnt sand can be dusted. When dried the surface will be very hard. A thin coat of black-lead, made with glue water, can now be brushed over them and again dried. They are now ready for use, and will stand any amount of handling. This method insures a clean split every time, and no trouble from blow-holes, from the fact that the material with which they are covered emits little if any gas when the molten iron comes against it.

## TO MAKE SQUARE AND RECTANGULAR COLUMNS.

It would surprise many of our first-class machinery moulders (who affect to despise the so-called housework shops) if they were to step inside one of the many foundries which make a specialty of architectural work, and see the admirable methods they have for pushing out work in short order. True, a great amount of the work done in these shops is of a very plain sort, requiring very little skill but any amount of muscle to accomplish; yet it must be conceded that some of the castings require men of superior ability to make them successfully.

We need only examine critically some of our large public buildings which have their fronts mainly of cast-iron, to be convinced that something more than ordinary skill was needed to mould the massive columns and entablatures of which the structure is composed.

The moulding of what are called square columns has always been considered a leading job in a housework shop, and the man who has uniform success in their manufacture commands good wages. A common method of moulding these castings is to ram the core (in green sand) on an arbor or core-iron made for the purpose; this arbor is simply a beam long enough to reach through each end, with bars cast or bolted along each side to support the sand. The core-box is usually a smooth board bedded alongside the mould, with loose sides clamped firmly together to the required width. When the core has been made in this, the sides are taken off, and then it can be lifted off the board and lowered into the mould. This is a rather delicate operation, and needs care to have it

exactly in the centre, otherwise the casting is sure to draw over on the thick side. To obviate this, studs have in some instances to be used to press the core over in the middle after the ends are secured in the centre.

Another method is to make the core in dry sand; but as this is only a makeshift at best, I will dismiss it at once, and proceed to explain the method which seems to me the surest as well as the most simple way of making square and rectangular columns, or any other casting similar in form; for I am persuaded that a considerable saving might

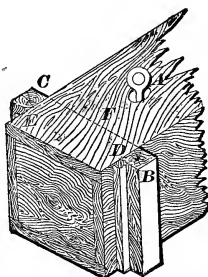


Fig. 261.

be effected in many of our machine-shops by adopting some ready mode of working with green-sand cores.

First, consider the pattern for a column 18 inches square—the one I have chosen for illustration being of such dimensions. The drawings are made isometrically and to scale, and the strictest attention has been paid to proportion throughout: by so doing I have been able to show all the details in actual position. Fig. 261 is a view of one end of the pattern: it is seen to be a plain block, and must be made long enough to meet all requirements; it is simply four stout boards well secured to blocks at short intervals along the inside; strong screw-plates must be let in on the under side and holes bored in the top, through

which to let down the screw for drawing out the pattern, as seen at *A*. The arrangement for stopping-off to the required length is simple. *B* and *C* are blocks which set against stops *D* and *E*. These stops are set back at a distance from *F* sufficient to allow the front face of blocks *B* and *C* being on a line with the mark *F*, such mark being the supposed length of the column required. When these blocks are drawn out they leave a true face against which to set the stopping-off cores. These cores are seen in position, and made good behind, at *A* and *B*, Fig. 262. The cores are about  $1\frac{1}{2}$  inches thick. The one at *A* has the running gates on its inner edge. An upright runner about  $1\frac{3}{4}$  inches square is set against the gates before ramming behind, to be connected with the main runner at the finish.

So much for the pattern. Let us now turn our attention to the mould, and begin by discarding the old method of bedding in the floor, for another which will not only give better results as to quality of work done, but quantity also. As before stated, the column chosen for the purpose of illustration is 18 inches square. By referring to Fig. 263 it will be seen that top and bottom flasks are used, prepared with hinges for the cope to turn in. These hinges serve a good purpose in this case, since, there being no necessity to lift the cope away to finish, you merely hitch on to the staple (not shown) in front, throw the cope back at a convenient angle for finishing, and prop up behind, leaving it resting in the hinges until ready for closing.

It must be plain to any one that there is a considerable saving of both time and room by this method of handling the cope.

The bottom flask is made up of loose sides and ends of the needed depth, held together by cross-bars bolted about every 2 feet along its length. As shown, it stands about 6 inches above the floor. This keeps the hinges and flange

clear, and gives greater freedom to the moulder whilst working at the job. By cutting out a gap in the side of the view I am enabled to give a sectional illustration of the whole job at that particular spot. The cross-bar is seen with broken line up the sides, which indicates the flanges for bolting together. The broken line at the

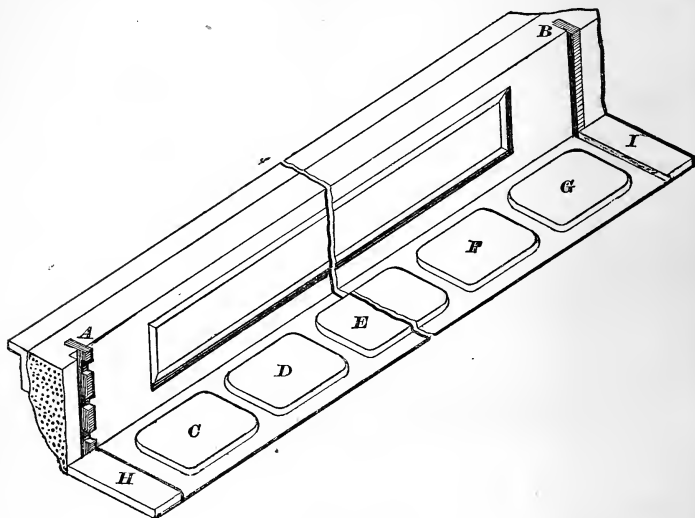


Fig. 262.

bottom of the bar indicates a flange 4 inches wide, which answers the double purpose of stiffening the bar and supplying a surface to resist the thrust when the pressure is on the mould.

The box must be made to take in the longest columns, as short ones can be moulded in it as readily as in a shorter one. As there are to be no core-prints on the pattern, it is only required to level a bed to the proper depth on which to lay the pattern, then ram up the sides and cope in the regular way, taking care to place the runners *C* and



*D*, Fig. 263, convenient for connecting with those behind the cores previously spoken of.

The pattern or block being drawn, and the mould finished, we will proceed to make the core, which will be rammed in the mould with very little trouble. Figs. 262 and 264 are views of the mould at different stages of the operation of moulding the column. It is supposed that all of the front side has been taken away, thus revealing the joint, side and bottom surfaces, with their several details, to be explained as we proceed. At Fig. 264 I have shown one of the loose patterns for the sides; it rests on the bottom of the mould. These patterns must be made of good and well-seasoned lumber, otherwise they will soon warp out of shape. They are to be the thickness of the casting required, with some draught allowed for easy drawing. The straps shown are of wrought-iron, and are sunk flush with the pattern. A toe is turned on the bottom, which grips the pattern, and they must be well secured with screws as shown. It will be seen at *A*, Fig. 264, that the stopping-off block has been taken out and the core previously spoken of set against the end of the pattern; but as it is not expected to cut these patterns to the length of column every time, the blocks at the opposite end remain where they are until the patterns have been taken out. The opening cores marked *CDEFG*, Fig. 262, are now to be set in their places, and the ones *H* and *I* must be set exactly in line with the front face of the blocks. All these cores are to be the thickness of the column on that side, and when in their places are to be covered with other cores made in lengths suitable for easy handling, and the width of the space between the side patterns. I have shown these cores in position from end to end in Fig. 264. If they are carefully made and fitted snugly together there will be no fear of any sand working its way down into the mould. After spreading a little sand all along

the cores, set down the beam or arbor, making sure that it rests solid on them all. I have shown a portion of this arbor in position at Fig. 264; it is simply a beam cast on its flat, in open sand, and can be used for all widths over 8 inches. When smaller than this it is safer to use a wrought-iron beam with holes drilled along its length. The plate being thin, it allows of more sand round the

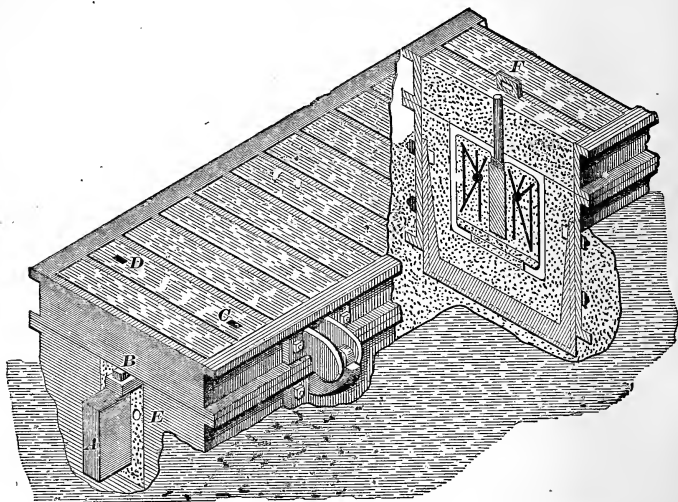


Fig. 263.

arbor, and is consequently safer. Fig. 265 will explain what I mean. If the reader will look at the cross-section of Fig. 263 he will see the disposition made of the core-arbor: the figure is purposely cut across the mould just where the stud is used for holding down the arbor; the stud is seen standing through the cope and resting on a loose packing, which is placed on the arbor a little below the surface of the core, to give extra thickness at that place.

The best material for making the core is the heap or

floor sand, not over-moist, but well mixed, and shook through a coarse riddle; but should the heap be very rotten on account of a preponderance of burnt sand, then a little new may be well mixed through it. Avoid adding sea-coal by all means, as it only creates gas, and there is quite sufficient for this purpose in the old sand which is used. I might add that it is best to face the runner end

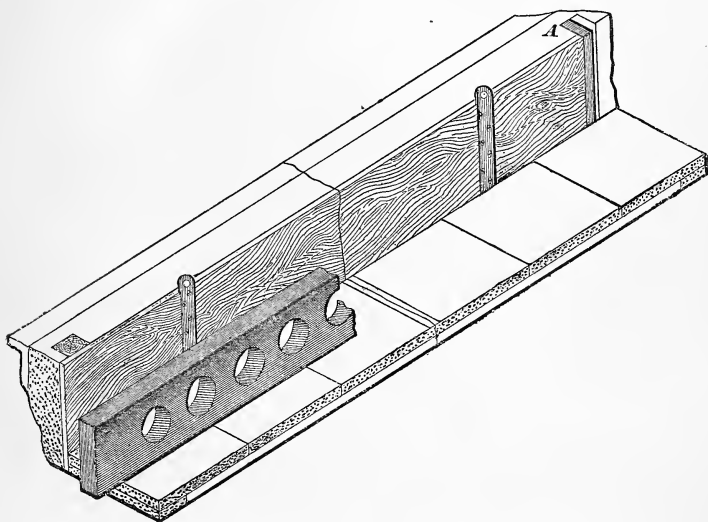


Fig. 264.

for a short distance with the regular facing-sand mixture, to prevent the gates from cutting the core at that spot.

To vent the core I have shown a  $\frac{3}{4}$ -inch rod laid on each side of the arbor, about two thirds of the distance from the bottom; when the ramming has reached within  $\frac{3}{4}$  inch from the top, vent in the direction of the rods, as shown in Fig. 3. These long rods must be drawn before the side patterns are taken out and shorter ones pushed in at

the ends, to be withdrawn after the cope is on and the ends secured. One of these vents is seen at *E*, Fig. 263. In ramming cores of this kind it is always best to put in a little at a time, in order to pack it solid without being unnecessarily hard.

All that remains to be done after the patterns are taken out is to set in the stop-off cores *A*, Fig. 262, with the upright runners, and connect with the cope runners, as previously directed.

I have shown in Fig. 263 a device for securing the arbor *A*. It projects through the ends of the flask, and is wedged under the cope at *B*; but provision must be made for holding it down in the middle also. It will be seen at



*F* that a clamp is cast in the box-bar, also in the next bar to it; but as this one has been taken away to admit of this view, it cannot be seen. The packing on the arbor must be placed so that the stud can be let down on it after the cope is on. A flat bar can be then pushed through the slot, which must rest on the stud, and a wedge at one or both ends secures it.

The column we have been considering is supposed to be a plain one on all its sides, and if panels or mouldings are added only on the top side, it makes very little difference to the moulding of the column. But often these embellishments are cast on one or both of the sides as well, as seen at Fig. 262. When this is the case, the best method of moulding such is as I suggest in the article on Hinged Flasks. But if a superior class of work is not desired, draw out the patterns and finish the mould, then set against the side strips of iron one-eighth or three-sixteenths thick, 6 inches wide and the full depth of the mould, from 9 to 12 inches apart, against which the patterns for the sides will be set (of course they will require to be as much thinner as is the thickness of the strips

used). The object of this is to prevent the patterns from rubbing against the finished mould whilst drawing them out.

By having iron strips, all the trouble from warping is obviated; if care is taken to have enough of them to prevent the ramming from pressing too hard against the mould, and thus leaving their impression, a very fair casting can be made this way.

By the adoption of this method much time is saved, and risk reduced to a minimum; also, the core being rammed in its place insures an absolutely even thickness, in consequence of which the result is a straight casting every time.

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## TO MOULD BEVEL-WHEELS WITHOUT A FULL PATTERN.

THE spindle and centre can be used to great advantage in the production of bevel-wheels, but it requires more than ordinary care on the part of both pattern-maker and moulder to make the plan a success. But if such care be exercised there is nothing to prevent as good work being made this way as can be got from the whole pattern.

I propose to show three methods of moulding a bevel-wheel by the aid of the spindle, each of which has claims for precedence, according to the form of wheel desired. To illustrate this article I have chosen an ordinary coarse-pitched wheel, about three feet in diameter, the plan and elevation of which is seen at Figs. 266 and 267. I do not purpose going into all the primary instructions for moulding such a wheel, as I take it for granted that any moulder who may be entrusted with this class of work will know

what preparations are needed to insure a good casting ; suffice it to say, that the centre, when set down in the floor, must be low enough to allow of the point of tooth marked *A*, Fig. 267, coming level with the floor of the shop. Care is needed in setting down the centre, as the spindle must be absolutely plumb before a start is made. I would also remind the moulder of the advisability of putting in a good cinder-bed (the use of which will be seen presently).

Fig. 266.

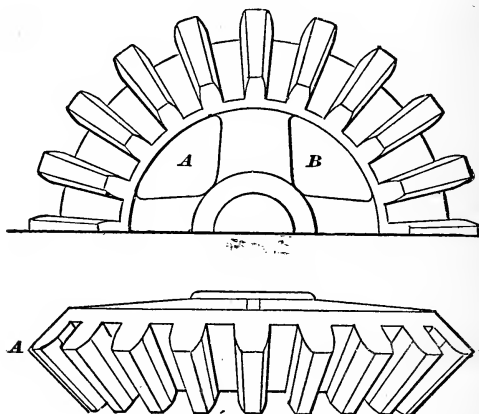


Fig. 267.

As I intend these instructions to serve for castings other than wheels, I shall be particular to give the reasons "why," in all cases where it will be advantageous to do so. It has been suggested that *A*, Fig. 267, is the starting-point or joint ; all above this point must come into the cope, and, necessarily, all below it will be in the floor. I speak now of the outer surfaces : the form of the wheel will determine what disposition we shall make of the inner surface, or arm-cores,—whether we shall lift them away on plates, use dry-

sand cores, or carry them in the cope. To better understand the several modes of procedure we will make our wheel by all the methods, beginning with the first mentioned, viz., lifting them away on plates. Fig. 3 will explain the matter. Point *A* corresponds with *A*, Fig. 2, and, as before stated, is the joint. *B* is a sweep attached to the spindle, and is intended to strike the exact form of the back of wheel; its edge is made to correspond with the top face of elevation, Fig. 2. This bed must be made hard and true, and in order to insure accuracy let all the sweeps be made with the top edge *C* at exact right angles to the spindle, so that a square resting thereon, and brought up to the spindle, will test their correctness.

You now have a true model of the back of the wheel, which must be prepared for parting and the cope rammed over it. An important item is to stake the box well before lifting it away, and take such pains as will preserve them and the joint from injury, while the rest of the mould is being made. The portion of mould above *A* has been obtained by striking a model and taking its impression as you would from a pattern; but the position below *A* will be obtained direct from the sweep *D*. The lower edge of this sweep corresponds with all the surfaces below the point *A*. The broken lines seen on this figure represent a section of the wheel cut across the centre, and will aid the understanding if carefully examined. I need not say that much precaution is needed in the preparation of this part of the mould, for accuracy as well as solidity.

In making this sweep it is well to have the surface *E* (which forms the bed for the teeth) made a little slack; this admits of the segment, with which the teeth are to be formed, being firmly set down in place. When the mould is swept, mark off the arms and set on the core-box; also put back sweep *B* and bring it into position at joint *A*. This will not only test the core-box, but will sweep off the

top of the cores exact with the impression taken in the cope. At *F*, Fig. 268, I have shown the lifting-plate in position. By referring to Fig. 266, at *A* and *B*, it will be seen that quite a large plate can be used in this case, thus enabling the moulder to make a safe core. A method for securing these cores is shown in article "Moulding Bevel and Mitre Wheels."

When the wheel is large in diameter and very deep, this

Fig. 268.

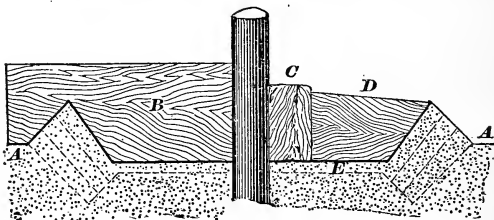
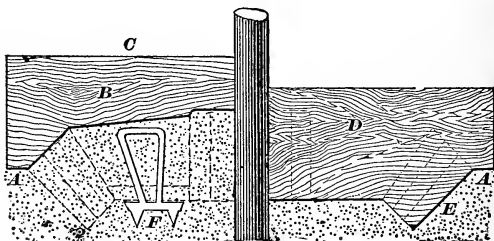


Fig. 269.

plan is the best, as the cores fit the places from whence they were taken with absolute certainty—something which cannot be said for dry-sand cores in hardly any case. It must be remembered, also, that there is no shipping of cores in and out of the oven. Should this wheel be made with dry-sand cores, the only deviation from the instructions given would be that, as soon as the bottom part of the



mould was swept, the teeth could be proceeded with at once, and the cores placed to thickness after the mould was finished. In setting in dry-sand cores it is well to have sweep *B*, Fig. 268, in position, so that they can be proved for depth, etc.

To carry the cores in the cope, it will be necessary to change the cope-sweep, and, instead of a core-box to form the arms and hub, these must be made as patterns, in the readiest way that suggests itself to the pattern-maker. Fig. 269 will explain this method, as in Fig. 268 the broken lines show the lower surfaces of the mould; the point *A* is still the joint, but it will be observed that the bottom edge of sweep *B* follows the line of thickness down the rim and along the arm. When this has been swept out, the hub and arm patterns can be set in position, as shown at *C* and *D*, Fig. 269. The ramming of this cope will not be as simple as in the former case, on account of the cores requiring to be secured to the cope by gagers and chucks, or grates bedded on the bottom and bolted up before the cope is lifted. When lifted off, the mould can be proceeded with as directed for Fig. 268. In this case cores the thickness of the web *E*, Fig. 269, and in the form of spaces *A* and *B*, Fig. 271, must be set into place after the mould is finished. For all shallow wheels, large or small, this plan is the best.

We now come to the all-important part of wheel-moulding, to wit, the teeth; and before entering on a description of the actual working of the methods herein suggested, it will be well to mention some of the evils we are accustomed to meet with in this line of work, such as swelled teeth, scabbed teeth, and wheels which evidence carelessness on the part of either pattern-maker or moulder, or both, from the fact of there being narrow and wide teeth all round the wheel. To make good sound teeth, sand must be used on which reliance can be placed—something which has

stood the test. When satisfied on this point, be sure to have it thoroughly mixed with the requisite quantity of sea-coal, and not over damp. Before commencing to ram a tooth, thrust a vent-rod through the middle of the space down into the cinder-bed below; ram a little at a time, firmly, but not too rashly, with a rammer made of wood; the bottom and all along the edge require special attention, otherwise soft places will be found. It is then that the

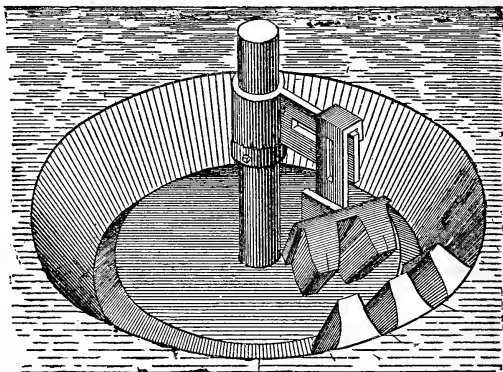


Fig. 270.

work of destruction begins if the tools are resorted to. Better destroy the tooth and make it over again, than to waste time in finishing and have bad teeth after all. By ramming the tooth with the vent-rod in place you are sure that all sides are equally benefited; the wire can be withdrawn when the top is reached, and the hole plugged. This relieves all anxiety about the iron entering the vent if there should be any fin or clearance when the cope comes on. To secure correctness in spacing, take the time necessary to do it right. If the segment should happen a little under or over, don't imagine that you can bring it all right

by making a little allowance either way as you go round, only to find yourself mistaken at the last move, and, rather than destroy what is done, shave off a little, or divide the difference, as the case may be; but try it again until it is right.

Fig. 270 is an isometrical view of the mould when swept as directed. The spindle is 3 inches in diameter, turned all its length. The arm is bored to fit snugly, and planed along the top side to a right angle with the bore. It is made to run loose on the spindle, and rests on a collar held in place by a set-screw. Instead of securing the segment to the arm proper, I have shown an attachment (which can be adjusted to the segment by the pattern-maker), the top inner surface of which is planed, and, as is seen, rests on the trued surface of the arm. The planed surfaces allow of an easy adjustment of the segment, without fear of altering the angle to which it was originally set. This arrangement admits of a set-screw being fitted on the top, by which means the segment can be lifted clear of the bed (when it is being tried around for the number of teeth) much quicker and without help.

The bracket, seen on the back of the segment, not only serves to secure it to the arm, but must be planed so that, when it is correct to the spirit-level, the face of the tooth will be at the angle required. When the segment is set correctly, put a bolt through the slot shown and screw fast, then lower the whole down into place and mark opposite the lines on centre of teeth all round to the starting-point. Should it be found to come a little under or over the number of teeth required, increase or decrease the diameter to suit the case, but be sure you are correct before commencing to ram the teeth, and take care to be exactly opposite the mark each move. The view shows three teeth rammed and the segment lifted clear of the last tooth, but it is not intended that the collar on which the arm rests shall be

disturbed, after it is once set, until all the teeth are made. When the teeth are finished take a segment or half-circle which fits the spindle and extends to the diameter of the core, and bed it round the spindle to form a seating in which to rest the core. Should a washer be required on the face or bottom side, similar to the one shown on the top, it can be done the same way. If proper care has been exercised on all the details of this job, it will be found, when closing the mould, that everything will find its place as surely as would have been the case if a full pattern had been used.

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### MOULDING BEVEL AND MITRE WHEELS.

MANY moulders consider the making of a bevel-wheel a simple job, but if they were made aware of the amount of time it takes to chip and trim the teeth, as also to correct other imperfections in the casting when made by the methods commonly in vogue, there is not the least doubt in my mind but that they would be led to say that, after all, it is not so easy and simple to make a good bevel-wheel.

No matter how popular the machine-made wheel may be, there will always be a great demand for wheels made from patterns when it is clear to the manufacturer that such wheels are needed often. This being admitted, it is important that the best method of moulding be adopted to secure a good casting, and at the same time inflict the least amount of damage to the pattern. As is well known, there are many ways of making a wheel from the pattern, some of which it may profit us to examine into. At the right of Fig. 271, marked *A*, is shown a very common method of

moulding such a wheel. The drawing represents a 6-foot bevel-wheel turned over in the bottom flask, and the top part rammed. It will be seen that wood-chucks are driven between the bars of the cope, down in between the arms, and lifters or gagers distributed over the surface to help bring up the sand. Now it must be plain to any one that

Fig. 271.

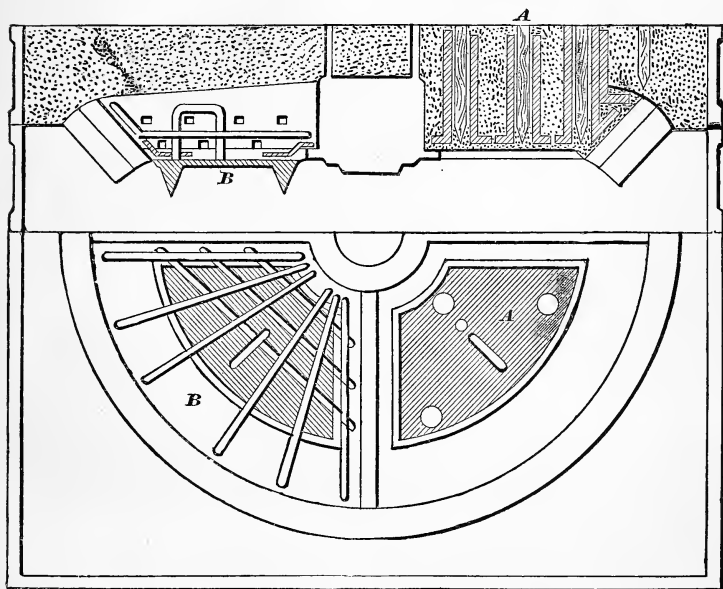


Fig. 272.

mischief must ensue either to mould or pattern, or both, when the separation takes place. If the pattern is held down to secure good teeth, then the arms suffer, for as a natural consequence much of the sand is dragged off the face of the mould which must be afterwards secured and made as good as the skill of the moulder can make it; but we know that although considerable time may be spent in

the mending, it is never as well done as it ought to be. In some foundries they attempt to remedy this evil by making the arms loose, and lifting them away with the cope, drawing them out when the box is turned over. And right here we have the cause of some of the extra labor in the machine-shop, for we all know that a pattern made with loose arms is unreliable. All wheel patterns should be made with the arms well secured to the rim. Again, at other foundries they partially save the arms at the expense of the teeth, by lifting the pattern with the cope, securing it with screws, and jarring it as it lifts from the teeth. But I need not say that it would require a much more elaborate arrangement than four wood stakes against the uneven sides of a box, and the uncertain guidance of a man at each stake or pin, to save the teeth from being disturbed. Usually, if the teeth are not actually pushed over, but more or less fractured, all that is considered necessary is to place the pattern back and go round with a hammer or mallet, and drive the pattern well down on its bed. It would certainly be ridiculous to expect a true wheel after such treatment of the mould, to say nothing of the damage done the pattern by such pounding. If, as is often the case, the teeth must be made over again, it is needless to say we may look out for chipping and trimming with a vengeance.

The method which secures the best results, both as to pattern and casting, is the one shown at *B*, Fig. 271 and Fig. 272. The joint of the flask is so arranged as to come level with the points of the teeth, the bars in the upper half being hollowed to fit the back of the wheel. A stout face-board is needed to correspond with pattern and flask, and after the bottom half is turned over, plates (such as shown in section at *B*, Fig. 271, and in plan at *A*, Fig. 272) are bedded down in their places. The joint being made for parting all round, all that is needed is to ram the cores,

securing them well with irons, after the manner shown in the drawing. Should it be considered necessary, irons of the requisite strength and shape may be cast in the plate to carry the back of core at *B*, Fig. 272; but where the plates are in constant use, these get broken off, and recourse must be had to the loose irons.

I think the plan Fig. 272, aided by section Fig. 271, will sufficiently explain the method of binding the cores together. When these are all well rammed and the cope lifted, they can be all lifted clean from the pattern and placed down on the three feet as shown, and the pattern taken out. It will be found that, if ordinary care has been taken in the operation, there remains little to do but close the mould as the pattern left it, exact,—a very desirable thing in any job. If a good loosening-plate be bolted through the hub of the wheel, there will be no necessity to strike the pattern throughout the whole process of moulding, so that the pattern at the finish must be as good as when it was placed on the face-board. Last but not least in the list of advantages secured by adopting this method is, that a wheel can be made very much quicker.

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### SPUR-WHEEL MOULDING FROM A SEGMENT AND SPINDLE.

No foundry should be without good facilities for moulding circular castings with sweeps; for if the necessary rig were always on hand numerous methods would suggest themselves to the founder, whereby much would be saved both in time and lumber in the making of many such castings.

Much loss is suffered by some firms because of the supposed cost of preparing the spindle and its adjuncts for this class of work, but I am persuaded that this supposition is purely imaginary, as I shall attempt to show.

All that is needed to secure good work by this method is to have the spindle of sufficient strength to support the sweep, and resist the thrust whilst it is being forced round.

Fig. 273 is a plan of the centre required, and Fig. 274 is a

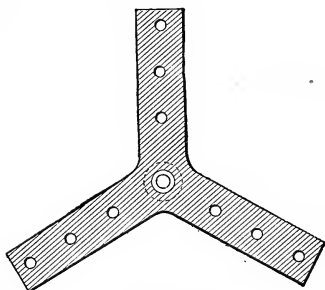


Fig. 273.

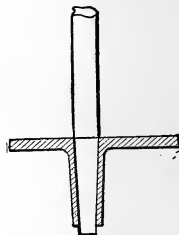


Fig. 274.

sectional elevation of the same with the spindle set in; its dimensions are as follows: Arms, 2 feet radius, 9 inches wide, 1 inch thick all through. The spindle shown is  $2\frac{1}{2}$  inches diameter, tapered to  $1\frac{1}{4}$  inches along 13 inches of its length at one end, so that, the hub in the centre being 12 inches deep, 1 inch of the spindle will protrude. Have the spindle no longer than is absolutely necessary to allow of 9 inches below the casting to top of centre, and as much above the mould as will allow of the sweep being firmly attached, as shown at Fig. 275.

Let the spindle be turned and tapered in the lathe, and after moulding the centre (in open sand) set it on end in the hub, pressing it down about 1 inch, taking care not to



have the centre reach above the taper when cast. To insure an easy withdrawal of the spindle, have a little tallow melted thin, with which to cover the taper end ; over this sprinkle a little fine parting-sand, and be careful when pouring the centre not to direct the stream of iron against it. Another important feature is to have the spindle at right angles with the centre.

By referring to Fig. 275 it will be seen that two kinds of

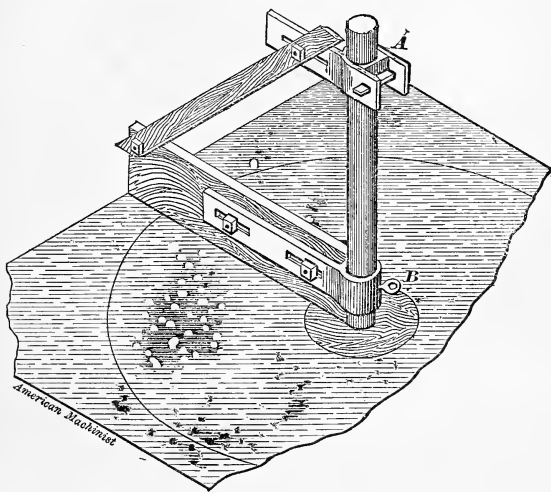


Fig. 275.

arms are shown for securing the sweep. The one shown at *A* will doubtless recommend itself to most moulders on account of there being no machine work needed in its construction. The one at *B* needs boring and also fitting with a set-screw: it is less troublesome to set, but it must be remembered that it can only be placed on and taken off by passing over the top of the spindle, whilst the one at *A* can be released on any part of it by simply knocking out the

key. Fig. 276 shows a bushing or collar to be screwed fast to the spindle when it is thought best to turn the arms loose on the spindle, as is sometimes the case.

The spur-wheel illustrated in this article is about 6 feet in diameter, 12 inches deep, 8 inches centre-core, and hub 14 inches deep, 4 inches thick; the arms have a centre-web and come flush with the rim, as shown in elevation on right hand half of Fig. 277. For such a wheel the centre must be sunk 2 feet below the floor, and to set it securely let the end of each arm rest on an iron block or weight firmly bedded down. This done, a hard bed is made level with

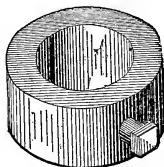


Fig. 276.

the floor and swept off, as seen at Fig. 275. The sweep and arms are now removed and a washer pattern, same diameter as the hub, and as thick as the distance the hub extends past the face (which in this case is 1 inch) is slipped over the spindle; the hole in centre of washer being made to fit the same, to insure a correct match with the cores. The cope is now rammed over the surface and staked at the corners; these stakes must be protected during the process of moulding the wheel, so that the cope when closed will be sure to rest in its original position. After the cope is lifted off and finished, a hole of the requisite dimensions must be dug and the washer again slipped over the spindle, round edge downwards, and bedded correct to depth. This can be accomplished either by marks made on the spindle, or from two points set in the joint to the cope-sweep, on which a straight-edge can rest,

The bottom bed can now be swept off similarly to the top, only that more care is needed to have the parts which form the casting as true as possible. I am aware that in ordinary practice all that is now required is to place the dry-sand teeth-cores in position, and set in the arm-cores, also made of dry sand; but a large experience in this class of work has convinced me that it is impossible to make a true spur-wheel by this method: for, however careful we may be to avoid it, the ugly fact still remains that no two cores are alike; consequently, the wheel must be untrue throughout its whole circumference, and is therefore untrustworthy. Spur-wheels thus made usually have short lives, and such as do not crash during the first few revolutions are broken

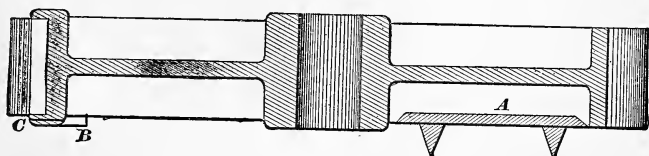


Fig. 277.

piecemeal, the faulty teeth snapping off from time to time, to be replaced by wrought-iron ones at considerable cost.

Fig. 278 will explain a method which obviates the difficulties spoken of. The core-box *A* for the arms is made so that the outside shall correspond with the thickness of the rim; on this the teeth must be secured, and the best way to effect this is to dovetail them on, so that they can be removed when not in use. After laying out the arms bed down lifting-plates shown in plan at *B*, Fig. 278, and in section at *A*, Fig. 277. The pattern can now be placed over and the cores rammed. I have shown a core ready for lifting away at *C*, Fig. 278; when the cores are all out, the way is clear for moulding the teeth. In this drawing I have purposely left out the spindle that I might more clearly explain

the arrangement for setting the teeth. The pattern sets back a little from the spindle, but an iron guide *D* is let in, which fits accurately and clips the spindle. This guide has a slot-hole in it, through which a good screw secures it to the pattern. By this method the pattern can be moved in

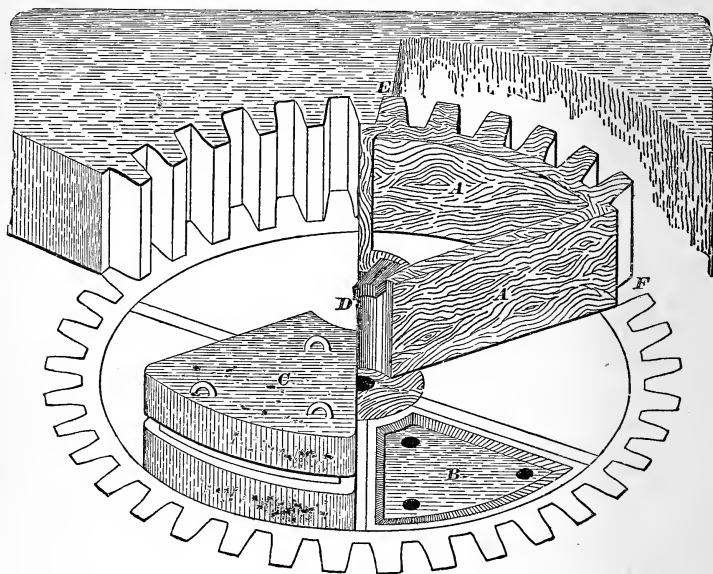


Fig. 278.

or out if it should be found necessary to alter the diameter. This, of course, will be discovered when the segment has been tried all round. Be sure of a well-defined mark all round the teeth before commencing to ram, and set the segment to them accurately each move that is made, and the result will be a comparatively true wheel.

The drawing shows the segment as having been rammed once and moved around; the side of tooth is set against the

sand at *E* and also to the tooth-mark at *F*. When the teeth are all rammed the spindle can be taken out and a piece of waste thrust in the centre hole, over which sand can be rammed firmly, level with the bottom of core-print.

The advantage gained by ramming the cores on the bed will be appreciated when the mould is ready for closing, as the feet will guide them to their respective places with absolute correctness. Another advantage is that cores and outside, being made from the same pattern, insures an exactness which cannot be expected by any other method.

Should it be required to cast a shroud over the teeth on the top side, cut the cope-sweep to correspond with the form and position of the shrouding; this will leave a sand pattern, as it were, the imperfections of which can be made good by finishing to a short segment pattern when the cope is lifted off. But should the shrouding be needed on bottom side as well, it will then be necessary to put back the bottom sweep (after the cores are all out), fitted with a tongue which will not only form the shrouding, but will also strike out clearance sufficient to allow of the segment being withdrawn after the teeth are rammed over it, as shown at *B*, Fig. 277.

A good method of making the segments to be used in forming the bottom shrouding is to halve them along their length so that they fit wedge form at the ends, the top half to have its thickest edge to the front; this of course allows the upper half to slide down the incline, freeing itself from the teeth as soon as it is touched—a desideratum to be appreciated. My meaning will be seen at once by consulting Fig. 277 at *C*.

The space at *B*, Fig. 277, will of course require filling up after the teeth are all rammed; this can be accurately done by using a segment made to clear the teeth when it is drawn out. The teeth will serve as a guide to set it by, and a few holes can be bored, through which spikes can be

difference (2 inches) has been attached to the under side of the web, thus making that side of the pattern correct. After bedding in the pattern thus prepared, make the parting inside the arms 2 inches above the web, as seen at *B*. (This is simply placing as much sand over the web as there is wood under it.) This is done by using a strickle made to rest on the top of the pattern and projecting down far enough to give the correct depth of sand over the web. The parting on the outside must be level with the top of pattern, as seen at *C*.

After this impression has been taken in the cope, two other strickles are needed—one to work round the outside down to *D* (Figs. 281 and 283), which will be 4 inches deep, of course. The other is for the inside, and must reach to *E* (Figs. 281, 282, and 283), and will be just 4 inches deeper than the strickle first used for the inside. After this is done it will be seen that the surfaces in the cope corresponding to *C* and *B* will now rest upon *D* and *E*, the difference being the same in both instances. In other words, *B* will exactly fit at *E*, because the distance from *D* to *E* corresponds with the lift in the cope.

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## A METHOD FOR MAKING IRREGULAR-SHAPED PIPES IN GREEN SAND.

THERE is in all probability hardly a foundry in existence that has not, in some part of its career, had more or less anxiety over the moulding of jobbing pipes. What is here meant by jobbing pipes are such as are called bends, elbows, tees, breeches, and all the varied forms of pipe needed for the trade. In some cases the anxiety arises from the lack of oven convenience for drying the cores;

whilst others again lament the cost of making the patterns and core-boxes, which in some instances is great, causing

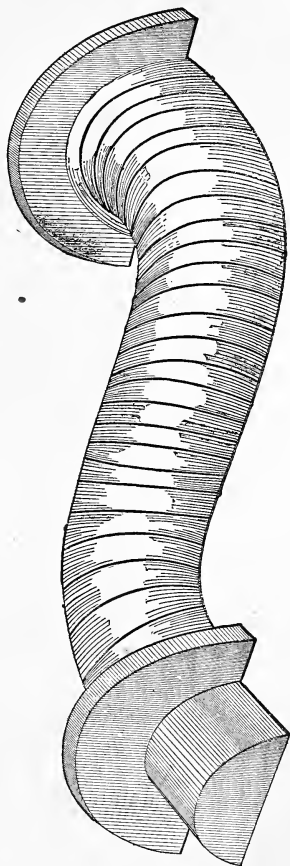


Fig. 284.

many owners of foundries to shun the business altogether. Strange as it may seem, it is nevertheless true, that the making of these pipes in the regular system is generally

distasteful to all concerned in their manufacture. The pattern-maker detests the frequent changes which must be made with the old patterns, on account of the dirt and nails with which they are usually covered,—these elements, as we all know, being deadly foes to the keen edge of his tools,—and the moulders almost universally say they would rather make anything else than pipes. To save expense, the plan of striking the thickness on the core, and moulding from a dry-sand or loam pattern is often resorted to; but, on the whole, this is a very poor substitute for the pattern and core-box correctly made.

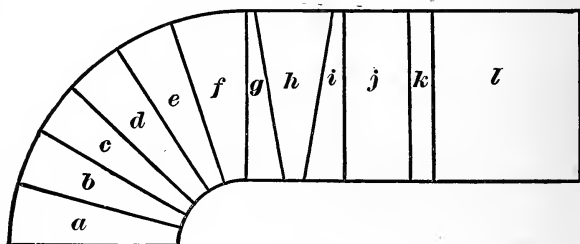


Fig. 285.

A very excellent method is adopted in some places where a large number of one kind of irregular pipe is required, which is, to cast the halves of the casting to be made: these are finished up and pinned together and used for the pattern, the core being made in green sand along with the mould. But such a pattern, valuable as it is for the purpose for which it was made, is utterly valueless for anything else.

The method herein suggested is in reality a modification of the one last mentioned, and fully meets the requirements of all interested, inasmuch as it can be made to answer for any and every kind of pipe required, be it circle, curve, or straight length, being simply as many half-



rings or sections of the required diameter and thickness as will form the halves of the pattern from which the casting is to be moulded. These in conjunction with the half-flanges and core-prints are always ready for any order that may come along, the only thing necessary to be made being the core-iron or arbor for the green-sand core ; thereby

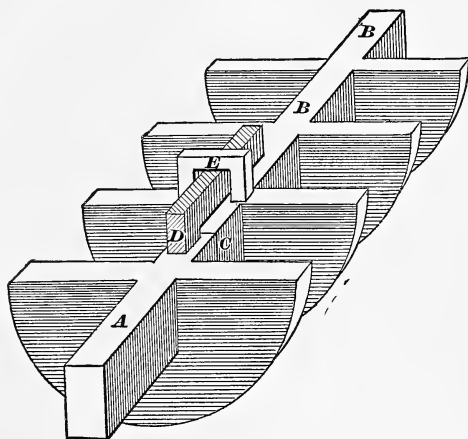


Fig. 286.

obviating all the difficulty connected with the lack of oven facilities, as well as cost of pattern making.

The engravings used to illustrate this subject will serve to explain the method more readily than could be done otherwise. Fig. 284 is a perspective view of the bottom half of an elbow pattern formed by the rings, with flanges and core-prints set in position ready for ramming into the bottom box. All the preparation needed is to have a templet of rough board cut out to the form of the inside of the pipe, to which the flanges can be secured. This being laid on the face board in the right position, the rings

previously spoken of must be placed over the templet or guide.

By referring to Fig. 285, which is a plan of elbow, with the sections or rings marked off, it will be seen that they are to be made tapering or wedge-shaped to any dimension suitable for the job, although it is well to make them as small as practicable, seeing that they must be made flat, and not to the circle or curve of the pattern; otherwise it would mar their usefulness in the places where it is nearly or altogether straight. The first six, *a, b, c, d, e, f*, are seen

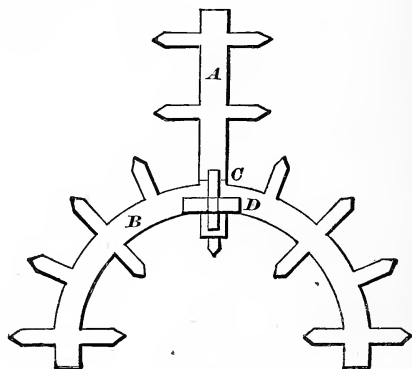


Fig. 287.

to be all alike, and fit, side by side, round the circle. At *g* and *h* is shown the use of odd rings, at different angles, in bringing the joints to the proper angle for taking either wedge or parallel sections, as shown at *i* and *j*. The moulder may use his own judgment as to the propriety of making parallel sections, as at *k* and *l*; for, as will be seen by referring to the plan at *g*, the wedges may be reversed alternately, thus answering for the straight sections of the pipe, as well as the curves. There will, of course, be some portions that the rings may fail in wholly covering; but

the ingenuity of the moulder will overcome any difficulty that may arise in that particular.

The bottom flask being rammed and turned over, the templet and core-prints removed, and after the prints have



Fig. 288.

been prepared for parting easily, the core must be rammed and formed in the inside, over which the top halves of the flanges and the rings are to be set, thus completing the pattern ready for the top flask. Nothing now remains but to finish the mould in the regular way.

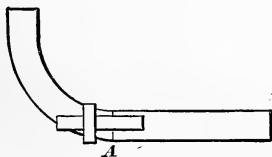


Fig. 289.

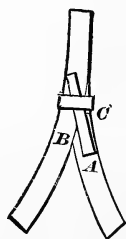


Fig. 290.

I think it will be plain to any practical moulder, that when he possesses a set of rings such as I have described he can make any form of pipe wanted, of the diameter and thickness for which the rings were made. The method must commend itself particularly to firms doing a large trade in crooked pipes, constantly changing in form, to suit the several places which they must fit. Very often they are made in loam, to save cost of pattern-making—a very expensive way of moulding such castings, we must

admit—all of which can be saved by the adoption of the method herein suggested. Of course I admit there is a limit to its usefulness, but do not hesitate to state that all pipes up to 18 inches diameter, of whatever form, may be successfully made at less than half the cost of making by the present methods.

One important item in the moulding of pipes by this method is the core-irons or arbors. Very often (when it could be easily avoided) the irons are made in one piece, and have

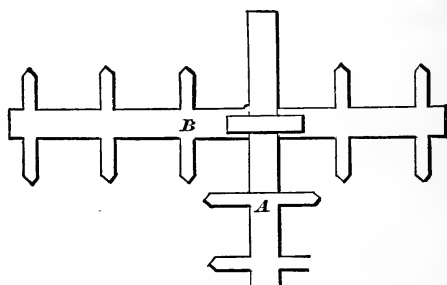


Fig. 291.

to be broken out, thus necessitating a new iron for each casting. There is really no need for this expense in the majority of instances, as they can be made in sections, cutting them at such places as will allow of their being drawn from the casting without having to be broken. Fig. 286 is a perspective view of the core-iron required, showing a plan of locking two irons together lengthwise. *C* is where the end of *A* meets *B*. In *A* is cast an iron, formed like the letter *L*, so that its under side will be level with the top of core-iron, as seen at *D*. A clamp, *E*, is cast in *B* to receive this iron, leaving space between for driving a hard-wood wedge, which will hold the two irons firmly together whilst the core is being made and handled. The wood expands as it absorbs moisture from the damp sand,

and is therefore becoming more firm all the time until cast. Then, of course, the wedge shrinks, or burns away; and gives freedom to the irons, making their withdrawal from the casting comparatively easy.

Fig. 287 shows plan of core-iron for a pipe of that form. *A* joins *B* at *C*, and the lock is seen at *D*. When cast, *A* can be pulled straight out, and *B* will travel in the direction of the circle. All pipes which are but segments of circles, such as Fig. 288, need only a plain iron, with suitable arrangements for handling, and are easily taken out.

Fig. 289 shows an elbow with long end. This iron joins

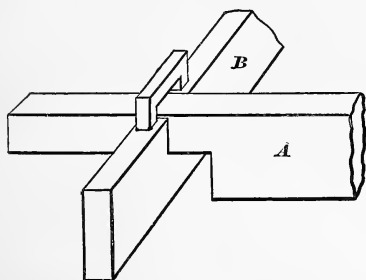


Fig. 292.

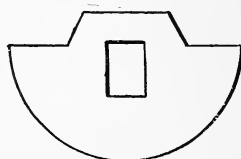


Fig. 293.

together at *A*, and the lock is as before shown. Fig. 290 is a plan of pipe often made. It will be seen that *A* joins *B* at *C*, making it easy to draw out each part separately.

Fig. 291 shows plan of core-iron for a tee or cross-pipe. As will be observed, it requires a somewhat different arrangement to meet this case. Let the reader refer to the perspective view of this iron at Fig. 292: it will be seen at a glance that a recess is left in core-iron *B* to receive the reduced end of *A*, which passes in under the clamp and is then wedged firmly to place. It will also be seen that the wings cannot be cast on the reduced end of *A*, conse-

quently loose ones are made to be slipped on after the two irons are braced together.

Fig. 293 shows the loose wing, the hole in which can be made large enough to admit of a wood wedge either under or over. These illustrations will, I think, be sufficient to give an idea of the system of core-irons needed to save the expense of making new ones every cast.

### MOULDING SMALL CASTINGS.

THERE are many ways of moulding small work where large numbers of one kind are required. Ordinarily when one or two only are wanted of a casting, such as is seen in plan and section at Fig. 294, the pattern is placed along

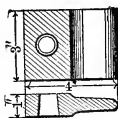


Fig. 294.

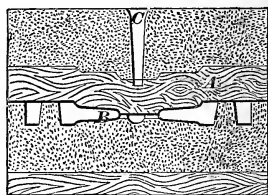


Fig. 295.

with others in a flask like the one shown at Fig. 296, taking care to joint down to the half of curve on the round edge, so that, after the impression of the top side has been taken in the cope or top part of flask, the pattern can be withdrawn, the gates to the various castings being cut with tools for the purpose. All this is proper where a different casting (or castings) are made in almost every flask; but such castings are in consequence very high in price, on

account of the extra time required to make them. But when a large order of one kind of casting is given, a much better method may be adopted. A good method is shown at Figs. 295 and 296, being an illustration of the match-board system, and eminently suited for this kind of work. Let Fig. 295 be turned so that the cope side is at the bottom, and it will be more readily understood. As will be seen, the match-board takes the correct form of pattern

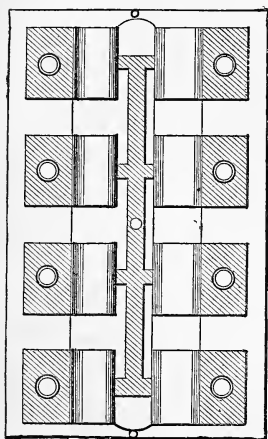


Fig. 296.

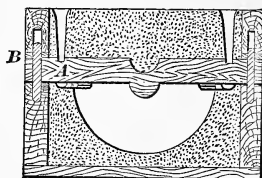


Fig. 297.

up to the half of curve, as seen at *B*. The patterns—eight in number—are made fast to this board as seen in plan at Fig. 296, the gates also being attached to board, the intention being that when the board is lifted off, all the patterns shall be drawn at once with the gates ready cut.

As this work is small, a snap flask will be all that is required to mould them. To accomplish this, let the match-board be large enough to pin on the flask, the pins being long, to reach through the board and into the upper half of flask, as seen at *A*, Fig. 297. Commence by

setting the flask down with board between, ram the nowel, and roll over on a rough board. (Let the engraving be now reversed, so as to have cope side on top.) Set in gate-pin *C*, and ram the cope; after lifting off the cope, tap the corners of the match-board and draw off.

Nothing remains now to be done but close the mould over eight washers, made in an incredibly short space of time.

Fig. 298 shows another kind of casting, which, if moulded

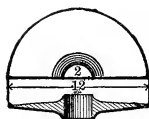


Fig. 298.

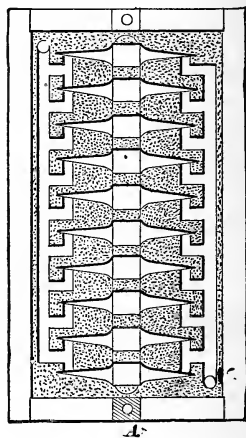


Fig. 299.

in the ordinary way, there would be very slow progress made. A match-board in plan is shown at Fig. 299; ten patterns are arranged with gates attached. Should there be any difficulty in drawing these patterns with the match-board, they can be placed on the board loose and drawn from the sand separately. A section of such a mould is shown at Fig. 297. As will be seen, a flask is needed for such a job as this. The flask is shown, but though the pins are seen at the sides, it is intended that they shall be



set in at the ends, as shown in plan, Fig. 299. Iron plates are of course secured to the edge of the flask through which the pin passes; these serve as a protection to the pin-hole. See *A*, Fig. 299, and *B*, Fig. 297.

The simplicity of this arrangement is apparent, and will recommend itself to any firm which once in a while receives an order for a large number of castings of a kind similar to those described, but have made them in the ordinary way on account of the cost of getting up an elaborate system of match-plates. The cost is trifling compared with the advantages gained, as very inferior men can readily turn off treble the quantity of work they have been accustomed to by the ordinary system.

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## A METHOD OF MOULDING PIPES AND COLUMNS.

ABOUT the year 1863 I was working at the Vauxhall Foundry, Liverpool, England; this firm had on hand at that time a large order of pipes for the corporation of that place. Some of these pipes were of considerable magnitude, and of such shape, sometimes, that the skill of the very best moulders was tasked almost to its limit to produce them successfully.

Large numbers of straight lengths were being swept on end in loam, and, where practicable, patterns were made for the production of others by the ordinary methods in green sand.

During this busy time I was much interested in some new arrangements which were being made for the production of straight socket-pipes 3 feet diameter and 10 feet long; but leaving the place before the plan was completed, I was

unable to witness the operation. However, I learned afterwards that it worked admirably.

Some five years after this a strike occurred at one of the shops in the town where I was then working, on account of one of these machines being introduced there for the moulding of small pipes, resulting finally, after great loss to all concerned, in its being adopted into the family of moulders employed there.

Twelve years ago I was standing in the gangway of Delamater's Foundry, New York City, when I was accosted by a man who claimed to be the original inventor of the above-mentioned machine, and, for a slight consideration, offered to make us a model of the same in wood. His offer was accepted, and to work he went, borrowing tools suitable for the occasion from the pattern-makers.

Model made to suit a short length of 6-inch pipe, he at once proceeded to make the mould, which proved to be a correct demonstration of all he had said—a really creditable piece of work.

The model was laid away for future consideration, and to the best of my knowledge was never brought out again, the business of the firm not being in that line.

I am aware that the great and increasing demand for cast-iron pipes has necessitated the building of large plants for their exclusive manufacture upon the most approved methods; in fact, some of the methods now in vogue are simply astounding, so rapid is the output, and of such excellent quality are the castings. Yet, all this admitted, there is considerable merit in the method herein explained; as much for its suggestiveness in the application of its principles to other kinds of work as well as to the object used for illustration. See Fig. 300.

The casting chosen for the purpose of explanation is a straight piece of 12-inch pipe or column. The first requisite for this method is a table or bed-plate on which to ram

the two parts of the flask, which may be made of wood or iron according as the magnitude of the job demands. These

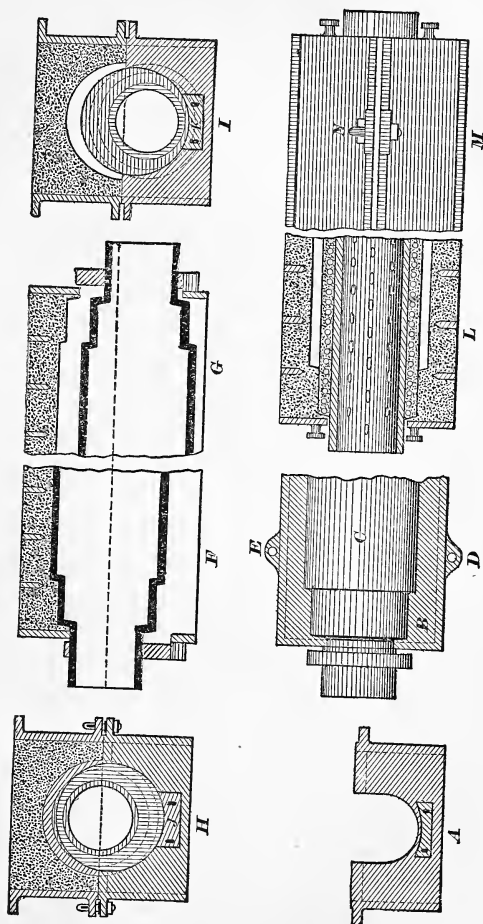


Fig. 300.

two parts must necessarily be cope or barred flasks, as they are to take the impression from the pattern, which remains

stationary on its bearings in the bed-plate. In order to accomplish this with accuracy, cams are secured to the ends of the pattern, which are to rest on adjustable bearings at each end of the bed-plate; this allows of the pattern being withdrawn before the cope is lifted off the bed-plate; a simple half turn of the pattern being sufficient to accomplish this.

If the job is a large one, suitable gearing can be secured at one end for this purpose, smaller patterns being easily revolved by a long bar inserted into holes at the end. The accompanying illustrations will enable the reader to understand the whole matter at a glance. *A* is an end elevation, and *B* is a plan of bed-plate with pattern *C* in position thereon. Lugs *D* and *E*, at both ends, must be arranged so that the cope and drag can be rammed on the one bed plate, either by inserting pins for the flask with holes and *vice versa* for the one with pins, or any other way which may suggest itself to the reader.

I have given at *F* a view of the pattern raised by the cam into position for ramming; and at *G* the pattern is shown clear of the mould above and ready for lifting away the flask.

The two sectional elevations *H* and *I* will show more clearly the working of this method; *J* and *K* are the adjustable bearings upon which the cam revolves, and when that side of the cam which is the furthest removed from the centre is resting on the bearing, the pattern is one half above and the other half below the face of the bed-plate, as seen at *F* and *H*, the opposite being the case at *G* and *I*, which shows the pattern resting on that side of the cam nearest the centre of the pattern and away from the mould.

At *L* I have shown a section of the upper and lower halves of mould when closed over the core; *M* being a side elevation of flask, showing lug *N* with the pin and key in position.

When the quantity of castings required will admit of such a rig being introduced, an amazing difference in the output will result, as will be readily understood when we consider that there is absolutely no finishing of the mould required.

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## INSTRUCTIONS FOR MAKING PATTERNS FROM MODELS, TEMPLETS, PLASTER CASTS, CARVED BLOCKS, ETC.

ALMOST every branch of the iron trade has its attractions, and strangers to the business are captivated when they witness for the first time the apparent wonders they see in the several departments of a well-equipped ironworks. But the foundry has claims on the uninitiated far greater than all the rest combined. Mystery seems to shroud the manipulations of the moulder, and they exclaim "Wonderful!" at every new revelation which presents itself to their astonished gaze.

Of course the average moulder does not share in this almost universal admiration for his trade: he considers it more or less a humdrum life, with plenty of hard work attending it, and hopes to get out of it as soon as he can. But in almost every foundry there is to be found, a few men who really like the work, and who are never so well pleased as when some job demanding more than ordinary ability to accomplish is given them to make.

I am aware that there is considerable sameness when the moulding to be done is from a pattern, and the same pattern every day; such an experience is certainly monotonous. Yet

even this has its advantages, inasmuch as such a job allows the mind free scope for other subjects; and if full advantage be taken of this opportunity for thought, much good may come out of it after all.

The subject I have chosen for this article is just such a one as must be interesting to all thinking moulders; and while I have selected but a few illustrations to work on, it will be seen that they are sufficient to explain the whole matter intelligibly, thus enabling the moulder to apply the principles to any other job of a like nature.

We will first consider what can be done with the templet and strickle. Fig. 301 is the sketch of a section of top and

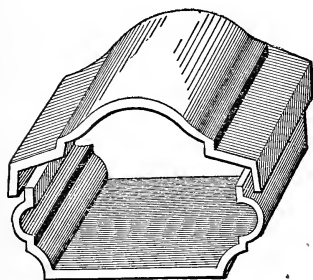


Fig. 301.

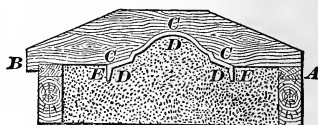


Fig. 302.

bottom railing about 9 inches wide and  $\frac{1}{4}$  inch thick all over. These are made in various lengths, some straight and others curved at one end. A few hours, at most, will serve to make such a pattern as this by the method under consideration, the only outlay for pattern work being the strickle and templet on which it is to travel. First consider a straight piece of pattern, say six feet long, and to the dimensions given for Fig. 301. Let it be the top half. By referring to Fig. 302 it will be seen at a glance. Such as this can be made readily in a flask by securing parallel pieces (planed to a true surface) on the edges of the flask, as seen

at *A*. The strickle is shown resting on these pieces, with stop *B* at one end, to guide it straight.

The first thing to be done is to ram the sand very hard in the flask, and strike off the form of top side of pattern; this is the line marked *C* on the strickle. If this is carefully done a true and hard surface is the result. Smooth over and dust on the parting sand, taking care to have no more on than is necessary to part the cope. Let the cope be evenly rammed on this and lifted away. Before proceeding to strike out the thickness the bed must be prepared, as in this condition it would be altogether too hard for the iron to rest on. After such preparation is made, then strike off the thickness, as shown at line marked *D*. I have shown a space outside the web at *E*. This is to aid in securing a good inner edge when the web is deep, leaving the outside to be made up with a piece of pattern the thickness required. All that is needed now is the right man to finish up the mould—one who has made the use of his tools a study. Such a man will turn out a pattern by this method, equal in every respect to the one made from a wooden model; in fact, very often much superior, as there is always great difficulty in keeping such light patterns in shape. Of course blocks can be made to fit them, but this is only adding still more expense; and why incur all this unnecessary outlay when it can be avoided with better results? All that is required when the pattern is to be other than straight is to have the bearings on which the strickle works made to the required curve or angle. Suppose we want a curve on one end with a rise or a droop; what more simple than to cast two straight-edges in lead? With these the problem is solved, for they can be bent to any form desired, and placed at the ends of the parallel straight-edges; thus furnishing the working plant for making any form of rail pattern required, or any other of a similar form.

Patterns for lintels, cornices, sills, etc., are usually required to be from  $\frac{1}{4}$  inch to  $\frac{3}{8}$  inch thick. If made of wood, they are very costly and are easily broken. An excellent method for making all such patterns is shown in Fig. 303, which is a perspective view of the templets *AB*, and strickle *C*, resting on the ends. The pattern intended to be made from these is a lintel, about 6 feet long, 1 foot 6 inches wide and 6 inches deep, with 10 inches rise in the arch. The design is to be as shown on the strickle. The guide-stop *D* can be on either side or on both. All that is required to make such a pattern is to level a bed on the floor on which to place the templet, then, after ramming in sufficient sand to form the mould, the strickle, which forms the outside of pattern to be made, must be first used, taking care to have the face true and hard. Should it be required to continue the design at each end, then guides *E* must be screwed on the ends of the templet, on which to work the strickle up and down. When this is done, take away the templet and finish well before the parting sand is used. Of course it requires care in placing the lifters and ramming the cope, so as not to disturb any of the sand model, but when properly done a good impression can be had. When the cope is lifted off, the templet must be replaced, and after the requisite preparations for venting, etc., have been made, proceed to ram the core, and with strickle No. 2 (which must have the required thickness allowed when made) proceed as directed for the outside.

I may be pardoned for again saying that unless a first-class workman be entrusted with this kind of work, good results cannot ensue, as there are so many points to be watched, such as the even ramming, correct finish, and an eye at all times to the draught required to insure a smooth working pattern.

Although I have not shown ends on the templet at Fig. 303, they can be put on when it is thought advantageous.



It will at once be seen that this method may be applied to a wide range of work, and that it costs comparatively nothing for pattern-making.

The strickle can be made equally efficacious in producing other forms of patterns; for circles are as readily made by it as those we have been considering. Fig. 304 is an elevation of a half base for an 18-inch column,  $\frac{5}{16}$  inch thick. By referring to Fig. 305 it will be seen that such a pattern can be made on the same principle as described for the flat surfaces. The strickle *A* works on circular bearings *BC* attached to the ends of flask *D*. The bearings are to be of the same diam-

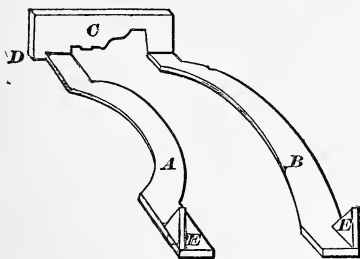


Fig. 303.

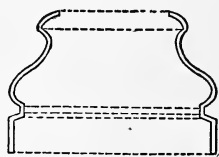


Fig. 304.

eter as the outside of ends of pattern required. The first strickle forms the outside, the impression of which is taken in the cope, after which the thickness is struck off, as before shown. But a much readier way is shown at Fig. 306 to make this pattern; the cope is there shown as the templet instead of the nowel. To do this it is necessary to have the cope barred to suit the job and rammed from the inside, making sure to have the joint good and firm. The first strickle in this case forms the surface in which the core is to be rammed, and after treating it in the same manner as before directed for parting, the nowel is rammed and both parts rolled over together. When the cope is again turned back,

strickle No. 2 is used to strike out the thickness, and this, of course, will be the outside of the pattern. As a rule, the latter method is the best, as it gives less trouble in ramming, and secures a better core with less labor. It is right to say here that when method shown at Fig. 306 is adopted, the ends must be of the same diameter as the inside of pattern.

Numerous illustrations might be given to show the adaptability of this method to the production of other circular patterns, but I feel sure that enough has been said to prove its adequacy; for by slight modifications of the system almost every emergency may be met successfully.

We will now consider the subject of making cast patterns from models, plaster casts, and carved blocks. Fig. 307 is the sketch of a newel-post, quite a familiar object, and needs no explanation. My reasons for selecting this post is because it furnishes capital opportunities for illustrating the method of making patterns from carved blocks. This post is supposed to be 12 inches square at the base and cap, and 3 feet high; such a post is usually made up of four thin slabs about  $\frac{1}{4}$  inch thick, mitred at the corners, and held together by internal fastenings. Being sold at so much apiece, it of course behooves the founder to keep them as light as possible, especially as competition in their manufacture is very keen. In fact, however massive any of this class of work may seem, we may rest assured that it is just as thin as the manufacturer knew how to make it. Some of this work is really handsome, and tests the skill of the carver to produce it, but carving out the face side is not the whole difficulty. If (as is sometimes attempted) the back is cut out to the desired thickness all over, the chances are that some parts will be cut through, whilst other parts will not be cut deep enough; and to avoid the former evil, it is considered best to be on the safe side, and the casting is consequently much heavier than it ought to be. All this

can be easily remedied by a very simple process. Fig. 308 is the perspective view of a slab of very plain design. It will be seen that in making such a slab from which to mould the pattern sufficient lumber must be used, either solid or built in layers, to suit the form of pattern, and high enough to leave the block firm after the deepest recesses have been cut out. The block is to be mitred on the sides its whole length, as seen at *A*; the line of thickness is also shown on the end at *BC*, and from this line let the block be well tapered at both ends.

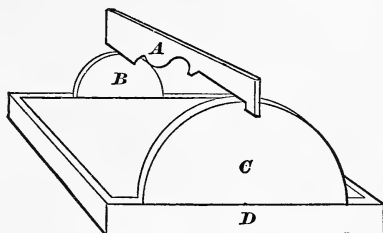


Fig. 305.

We will now show how to make a cast pattern from this block  $\frac{1}{4}$  inch thick. To do so, we require two copes that are an exact fit to the same nowel. Let the block be set face up (convenient for easy moulding) in cope No. 1 in the customary way for rolling over. Ram the nowel very hard and roll over both parts together. In making the joint, be sure of a little surface past the feather-edge (for reasons to be explained further on), and be careful to have the joint at the ends exact to the thickness line; this impression must now be taken in cope No. 1, which must also be rammed extra hard. Lift off the cope and lay back on soft sand, draw out the block and proceed to lay in the thickness, which will be made of clay, after this manner: The best clay for the purpose is the red, smooth kind; have it dried and crushed; then sift through a fine sieve and mix

the consistency of stiff putty. Now lay two strips  $\frac{1}{4}$  inch thick on a smooth board as far apart as required, and roll out the clay between. All that is now needed is a knife and a little ingenuity, and the clay may be cut and laid on the hard mould with the greatest accuracy, every part of the surface being correct to thickness. It will now be seen why the bottom was to be rammed so hard the first time, and also why the joint was to be extended past the feather-edge; in the latter case the thickness can stand past the edge a little when laid on, and pared off even with the joint

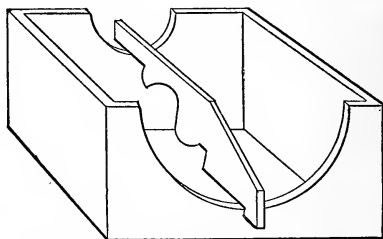


Fig. 306.

afterwards. Now prepare for parting, and take this impression in cope No. 2. (This will be the top part of mould and the back of pattern.) Should there be intricate parts in the lift, clamp the two parts together and roll them both back on a soft bed. You can now loosen the nowel and lift the sand away carefully without disturbing any of the mould in the cope. When the clay is removed you have a perfect impression. In finishing this, be careful to give good draft where it is needed. The necessity of cope No. 1 is now seen, for the joint in this is the same impress as that in cope No. 2, and nothing remains to be done but to place in the back, bring on the nowel, and ram so as to give a good, even casting. When this is turned over, cope No. 1 ends its usefulness by leaving you the joint exactly

corresponding with the impression taken in cope No. 2, so that you have an absolute fit when they are placed together, and an even thickness at every part of the pattern. Should the design be very elaborate, with many delicate edges, it will facilitate the thickening very much if a coat of plaster be run over the pattern instead of the hard ramming as

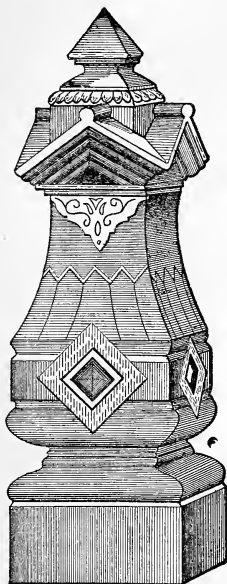


Fig. 307.

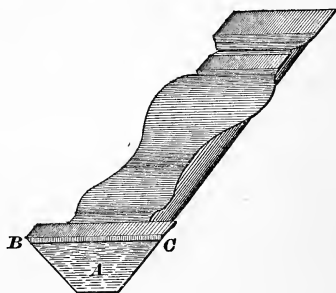


Fig. 308.

directed, thus leaving a good hard face to lay the clay to. This is best where there is very fine carving and the pattern is to be extra light, such as for ornaments, fine mouldings, and all patterns for decorative purposes.

When the model covers a large space it is customary for the designer to have it cast in plaster sections to insure easy and safe shipments. To make a pattern from such sections it will (in the majority of instances) be found best to cast

the face in the cope. These sections will have no regular form on the back, as there is no particular attention paid to that part of the model, only to have sufficient body of plaster to take in the deepest recesses; it will therefore require some modifications of the previous instructions to make such patterns face side up. Let the nowel be placed on the floor and proceed to arrange the sections of model (face up) in such a manner as will be most convenient for moulding, and be sure that all the several pieces have a solid bearing, so that the ramming of the cope will not disturb any of them. As before, there will be copes No. 1 and No. 2 in this case. After the joint has been rammed very hard it must be formed carefully all round, and the whole face prepared for separation. Cope No. 1 will be now used, and as this will be for the mould proper, every precaution must be taken to secure a good face; and when rammed it must be lifted off and placed aside. Now bring on cope No. 2, and be sure to ram the face of this as hard as possible; when this is laid back on the floor the clay thickness is to be laid on accurately all over the impress of model as before shown, and after the necessary preparations for an easy separation have been made the nowel must be rammed, due precautions being taken to secure a good mould. The whole can now be rolled back and the cope lifted off carefully, so as not to disturb any of the mould under the clay. Nothing more is required but to finish cope No. 1 and the nowel, and then close. The joints of course will correspond, for although the nowel-joint is the impress of cope No. 2, it must be remembered that both copes were rammed on the same joint, before the nowel was lifted to be rammed on cope No. 2.

I shall be excused, I think, for so much apparent repetition in these instructions, because I know that, to those who have had no experience in this class of work, there seems more or less mystery in the use of two copes; but a little

thought will overcome all this, and the whole thing appear in all its simplicity. To foundries where no pattern-makers are employed a knowledge of the methods is indispensable, as it places them (so far as this class of work is concerned) on an equal footing with the best-equipped firms.

To conclude: I would say that many ingenious contrivances will suggest themselves to the moulder engaged on this line of work; as, for instance, a rough block with bearings for a strickle to work on can be struck off in plaster to any design which runs the same along its whole length; this can be used as a model and backed out with clay thickness as directed. All such patterns as are shown at Fig. 301 can be treated this way, thereby enabling the moulder to choose either the method explained at Fig. 302 or the one just considered. In fact, this article is but a mere outline of what can be done by these methods; for when once entered into it will be found that scarcely any limit can be placed to its usefulness.

## PART VI.

### *MISCELLANEOUS ITEMS, RECIPES, TABLES, ETC.*

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#### USEFUL RULES OF MENSURATION.

##### MENSURATION OF THE CIRCLE, CYLINDER, SPHERE, SQUARE, ETC.

(1) The areas of circles are to each other as the squares of their diameters.

(2) The diameter of a circle being 1, its circumference equals 3.1416.

(3) The diameter of a circle is equal to .31831 of its circumference.

(4) The square of the diameter of a circle being 1, its area equals .7854.

(5) The diameter of a circle multiplied by .8862, or the circumference multiplied by .2821, equals the side of a square of equal area.

(6) The sum of the diameters of two concentric circles multiplied by their difference and by .7854 equals the area of the space or ring contained between them.

(7) The sum of the thickness and internal diameter of a cylindric ring multiplied by the square of its thickness and by 2.4674 equals its solidity.

(8) The circumference of a cylinder multiplied by its length or height equals its convex surface.

(9) The area of the end of a cylinder multiplied by its length equals its solid contents.

(10) The square of the diameter of a sphere multiplied by 3.1416 equals its convex surface.



(11) The cube of the diameter of a sphere multiplied by .5236 equals its solid contents.

(12) The height of any spherical segment or zone multiplied by the diameter of the sphere of which it is a part and by 3.1416 equals the area of the convex surface of the segment; or,

(13) The height of the segment multiplied by the circumference of the sphere of which it is a part equals the area.

(14) The solidity of any spherical segment is equal to three times the square of the radius of its base plus the square of its height, and multiplied by its height and by .5236.

(15) The solidity of a spherical zone equals the sum of the squares of the radii of its two ends and one third the square of its height multiplied by the height and by 1.5708.

(16) The side of a square equals the square root of its area.

(17) The diagonal of a square equals the square root of twice the square of its side.

(18) The side of a square is equal to the square root of half the square of its diagonal.

(19) The side of a square equal to the diagonal of a given square contains double the area of the given square.

#### OF TRIANGLES, POLYGONS, ETC.

(20) The complement of an angle is its defect from a right angle.

(21) The supplement of an angle is its defect from two right angles.

(22) The area of a triangle equals half the product of the base multiplied by the perpendicular height; or,

(23) The area of a triangle equals half the product of the two sides and the natural sine of the contained angle.

#### ELLIPSES, CONES, ETC.

(24) The product of the two axes of an ellipse multiplied by .7854 equals its area.

(25) The curve surface of a cone is equal to half the product of the circumference of its base multiplied by its slant side; to which if the area of the base be added the sum is the whole surface.

(26) The solidity of a cone equals one third of the product of its base multiplied by its altitude or height.

(27) The squares of the diameters of the two ends of the frustum of a cone, added to the product of the two diameters, and that sum multiplied by its height and by .2618, equals its solidity.

### CAST-IRON ALLOYS.

To TOUGHEN CAST-IRON.—10 to 15 per cent of wrought-iron scrap (stirred in);  $\frac{1}{4}$  of 1 per cent of copper (stirred in).

### WEIGHT OF CAST-IRON BALLS IN POUNDS.

Dia.	Weight.	Dia.	Weight.	Dia.	Weight.	Dia.	Weight.	Dia.	Weight.
1	.137	3 $\frac{3}{8}$	7.22	6 $\frac{1}{2}$	38	9 $\frac{1}{4}$	109	12	237
1 $\frac{1}{8}$	.194	3 $\frac{7}{8}$	7.97	6 $\frac{3}{8}$	40	9 $\frac{3}{8}$	113	12 $\frac{1}{2}$	268
1 $\frac{1}{4}$	.265	4	8.76	6 $\frac{1}{2}$	43	9 $\frac{1}{2}$	118	13	301
1 $\frac{3}{8}$	.354	4 $\frac{1}{8}$	9.61	6 $\frac{3}{4}$	45	9 $\frac{5}{8}$	123	13 $\frac{1}{2}$	338
1 $\frac{1}{2}$	.461	4 $\frac{1}{4}$	10.51	7	47	9 $\frac{3}{4}$	127	14	376
1 $\frac{5}{8}$	.587	4 $\frac{3}{8}$	11.47	7 $\frac{1}{8}$	50	9 $\frac{7}{8}$	132	14 $\frac{1}{2}$	418
1 $\frac{3}{4}$	.732	4 $\frac{1}{2}$	12.48	7 $\frac{1}{4}$	53	10	138	15	463
1 $\frac{7}{8}$	.902	4 $\frac{3}{4}$	13.5	7 $\frac{3}{8}$	55	10 $\frac{1}{8}$	143	15 $\frac{1}{2}$	511
2	1.09	4 $\frac{7}{8}$	14.6	7 $\frac{1}{2}$	58	10 $\frac{1}{4}$	148	16	562
2 $\frac{1}{8}$	1.31	4 $\frac{7}{8}$	15.8	7 $\frac{3}{8}$	61	10 $\frac{3}{8}$	153	16 $\frac{1}{2}$	623
2 $\frac{1}{4}$	1.56	5	17.1	7 $\frac{1}{2}$	64	10 $\frac{1}{2}$	159	17	674
2 $\frac{3}{8}$	1.83	5 $\frac{1}{8}$	18.4	7 $\frac{3}{8}$	67	10 $\frac{5}{8}$	165	17 $\frac{1}{2}$	735
2 $\frac{1}{2}$	2.13	5 $\frac{1}{4}$	19.8	8	71	10 $\frac{3}{4}$	171	18	799
2 $\frac{3}{4}$	2.47	5 $\frac{3}{8}$	21.2	8 $\frac{1}{8}$	74	10 $\frac{7}{8}$	177	18 $\frac{1}{2}$	868
2 $\frac{7}{8}$	2.84	5 $\frac{1}{2}$	22.7	8 $\frac{1}{4}$	77	11	183	19	940
3	3.25	5 $\frac{3}{4}$	24.3	8 $\frac{3}{8}$	81	11 $\frac{1}{8}$	189	19 $\frac{1}{2}$	1016
3 $\frac{1}{8}$	3.69	5 $\frac{7}{8}$	26.0	8 $\frac{1}{2}$	85	11 $\frac{1}{4}$	196	20	1097
3 $\frac{1}{4}$	4.17	5 $\frac{7}{8}$	27.5	8 $\frac{5}{8}$	88	11 $\frac{3}{8}$	202	20 $\frac{1}{2}$	1181
3 $\frac{3}{8}$	4.70	6	29.5	8 $\frac{3}{4}$	92	11 $\frac{1}{2}$	209	21	1269
3 $\frac{1}{2}$	5.26	6 $\frac{1}{8}$	31.7	8 $\frac{7}{8}$	96	11 $\frac{3}{4}$	216	22	1459
3 $\frac{3}{4}$	5.87	6 $\frac{1}{4}$	33.4	9	100	11 $\frac{7}{8}$	223	23	1667
3 $\frac{7}{8}$	6.32	6 $\frac{3}{8}$	35.4	9 $\frac{1}{8}$	105	11 $\frac{7}{8}$	230	24	1894

TABLE

SHOWING THE WEIGHT OR PRESSURE A BEAM OF CAST-IRON WILL SUSTAIN WITHOUT DESTROYING ITS ELASTIC FORCE WHEN IT IS SUPPORTED AT EACH END AND LOADED IN THE MIDDLE.

All the Beams are one inch thick.

Depth in Inches.	Length 6 feet.	Length 7 feet.	Length 8 feet.	Length 9 feet.	Length 10 feet.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
3	1,278	1,089	954	855	765
3½	1,739	1,482	1,298	1,164	1,041
4	2,272	1,936	1,700	1,520	1,360
4½	2,875	2,450	2,146	1,924	1,721
5	3,560	3,050	2,650	2,375	2,125
6	5,112	4,356	3,816	3,420	3,060
7	6,958	5,929	5,194	4,655	4,165
8	9,088	7,144	6,784	6,080	5,440
9		9,801	8,586	7,695	6,885
10		12,100	10,600	9,500	8,500
11			12,826	11,495	10,285
12			15,264	13,680	12,240
13				16,100	14,400
14				18,600	16,700

CHAPLETS.

Thickness of Column.	Diam. of Stud.
½", ⅝", ¾", 7⁄8"	½"
1", 1⅛", 1¼"	⅝"
1⅜", 1½", 1⅝", 1¾"	¾"
1⅞", 2", 2⅛", 2¼", 2⅝"	7⁄8"
2⅞", 2⅝", 2¾", 2⅞"	1"
3", 3⅛", 3¼"	1⅛"

WEIGHT IN POUNDS OF CIRCULAR PLATES ONE INCH  
THICK FROM 1 TO 103 INCHES IN DIAMETER.

Dia.	Weight.	Dia.	Weight.	Dia.	Weight.	Dia.	Weight.	Dia.	Weight.
1	.204	11½	27	25	128	54	596	94	1805
1½	.459	11¾	29	25½	133	55	618	95	1843
2	.618	12	30	26	139	56	641	96	1882
2¼	1.04	12¼	31	26½	144	57	664	97	1922
2½	1.27	12½	32	27	149	58	687	98	1962
2¾	1.55	12¾	34	27½	156	59	711	99	2002
3	1.84	13	35	28	161	60	736	100	2043
3¼	2.16	13¼	36	28½	166	61	760	101	2084
3½	2.51	13½	38	29	172	62	785	102	2125
3¾	2.90	13¾	39	29½	178	63	811	103	2167
4	3.27	14	41	30	184	64	837	104	2208
4¼	3.69	14¼	42	30½	190	65	863	105	2252
4½	4.14	14½	43	31	197	66	890	106	2295
4¾	4.61	14¾	45	31½	203	67	917	107	2339
5	5.11	15	46	32	210	68	945	108	2382
5¼	5.43	15¼	48	32½	216	69	973	109	2427
5½	6.18	15½	50	33	223	70	1001	110	2472
5¾	6.76	15¾	51	33½	230	71	1030	111	2517
6	7.35	16	53	34	237	72	1059	112	2562
6¼	7.98	16¼	54	34½	244	73	1089	113	2608
6½	8.63	16½	56	35	251	74	1119	114	2655
6¾	9.41	16¾	58	35½	258	75	1149	115	2700
7	10.10	17	60	36	265	76	1180	116	2748
7¼	10.74	17¼	61	37	280	77	1211	117	2783
7½	11.49	17½	63	38	295	78	1243	118	2834
7¾	12.27	17¾	65	39	311	79	1275	119	2892
8	13.10	18	67	40	327	80	1307	120	2941
8¼	13.85	18¼	70	41	344	81	1340	121	2990
8½	14.77	18½	74	42	361	82	1374	122	3040
8¾	15.64	18¾	78	43	378	83	1407	123	3090
9	16.55	19	82	44	396	84	1441	124	3141
9¼	17.48	19¼	86	45	414	85	1477	125	3191
9½	18.43	19½	91	46	433	86	1510	126	3243
9¾	19.42	19¾	93	47	452	87	1546	127	3294
10	20.42	20	99	48	471	88	1588	128	3346
10¼	21.4	20¼	104	49	491	89	1618	129	3399
10½	22.5	20½	109	50	511	90	1655	130	3452
10¾		20¾	113	51	532	91	1692		
11	25	21	118	52	553	92	1729		
11¼	26	21¼	123	53	574	93	1767		

TABLE OF DIMENSIONS AND WEIGHTS OF SHORT-LINKED CHAINS AND ROPES, AND PROOF OF CHAIN IN TONS.

HASWELL.

Dia. of Chain.	Weight per Fathom.	Proof Strain.	Circumference of Rope.	Weight of Rope per Fathom.	Chains for cranes should be made of short oval links, and should not exceed one inch in diameter. The ropes of the sizes given are considered to be of equal strength with the chains, which being short-linked are made without studs. — HASWELL.
Inches.	Lbs.	Tons.	Inches.	Lbs.	
$\frac{5}{16}$	6	.75	$2\frac{1}{2}$	1.5	
$\frac{3}{8}$	8.5	1.5	$3\frac{1}{4}$	2.5	
$\frac{7}{16}$	11	2.5	4	3.75	
$\frac{1}{2}$	14	3.5	$4\frac{3}{4}$	5	
$\frac{9}{16}$	18	4.5	$5\frac{1}{2}$	7	
$\frac{5}{8}$	24	5.25	$6\frac{1}{4}$	8.7	
$\frac{11}{16}$	28	6.5	7	10.5	
$\frac{3}{4}$	32	7.75	$7\frac{1}{2}$	12	
$\frac{13}{16}$	36	9.25	$8\frac{1}{4}$	15	
$\frac{7}{8}$	44	10.75	9	17.5	
$\frac{15}{16}$	50	12.5	$9\frac{1}{2}$	19.5	
1	56	14	10	22	

TEMPLETON.

Dia. of Chain.	Proof Strain.	Dia. of Chain.	Proof Strain.	Dia. of Chain.	Proof Strain.
Inches.	Tons.	Inches.	Tons.	Inches.	Tons.
$\frac{5}{16}$	1	$\frac{9}{16}$	5	$\frac{13}{16}$	$11\frac{1}{4}$
$\frac{3}{8}$	2	$\frac{5}{8}$	6	$\frac{7}{8}$	13
$\frac{7}{16}$	3	$\frac{11}{16}$	8	$\frac{15}{16}$	15
$\frac{1}{2}$	4	$\frac{3}{4}$	$9\frac{1}{4}$	1	18

## TO MEND CASTINGS.

TO MEND HOLES IN CASTINGS.—Sulphur in powder, 1 part; sal-ammoniac in powder, 2 parts; fine iron borings, 80 parts. Make into a thick paste and fill the holes.

NOTE.—These ingredients can be kept separate, and mixed when required.

Sulphur, 2 parts; fine black-lead, 1 part. Melt the sulphur in an iron pan; then add the lead; stir well and pour out. When cool, break into small pieces. A sufficient quantity being placed on the part to be mended can be soldered with a hot iron.

CEMENT FOR COVERING SCARS OR STOPPING HOLES IN CASTINGS.—(This will resist fire or water.)—Equal parts of gum-arabic, plaster of Paris, and iron filings. A little finely pulverized white glass added to this mixture makes it still harder. Keep in a dry state, and mix with water when wanted.

TO FILL HOLES IN CASTINGS.—Lead, 9 parts; antimony, 2; and bismuth, 1. Melt together and pour in. (Expands in cooling.)

#### WEIGHT OF ONE CUBIC INCH OF DIFFERENT METALS IN POUNDS.

Metal.	Lbs.
Brass (average).....	.3023
Bronze.....	.306
Copper, cast.....	.3135
Gold, pure.....	.6965
Iron, cast.....	.2622
Iron, wrought.....	.282
Lead, cast... ..	.415
Steel.....	.281
Tin, cast... ..	.263
Zinc, cast.....	.26
Antimony.....	.242
Bismuth.....	.355
Manganese.....	.289
Silver.....	.378
Platinum.....	.735
Cadmium.....	.312
Potassium.....	.031

WEIGHT OF DIFFERENT SUBSTANCES IN POUNDS.

	Cubic Inch.
Antimony.....	.242
Bismuth.....	.355
Brass.....	.319
Bronze.....	.314
Manganese.....	.289
Mercury.....	.491
Nickel.....	.318
Fresh water.....	.03617
Sand.....	.055
Coal.....	.0452
Brick.....	.0723
Oak.....	.0351
Ash.....	.0305
Cork.....	.0087
Pitch pine.....	.024

CAPACITY OF CISTERNS FOR EACH 10 INCHES IN DEPTH.

Feet Diameter.	Galls.	Feet Diameter.	Galls.
2.....	19.5	8.5.....	354
2.5.....	30.6	9.....	397
3.....	44.07	9.5.....	442
3.5.....	59.97	10.....	490
4.....	78.33	11.....	593
4.5.....	99.14	12.....	705
5.....	122.4	13.....	828
5.5.....	149	14.....	960
6.....	177	15.....	1102
6.5.....	207	20.....	1959
7.....	240	25.....	3060
7.5.....	276	30.....	4407
8.....	314		

## THE FRACTIONAL PARTS OF AN INCH IN DECIMALS.

$\frac{7}{8}$	=	.875		$\frac{7}{8}$	+	$\frac{1}{16}$	=	.9375
$\frac{3}{4}$	=	.75		$\frac{3}{4}$	+	$\frac{1}{16}$	=	.8125
$\frac{5}{8}$	=	.625		$\frac{5}{8}$	+	$\frac{1}{16}$	=	.6875
$\frac{1}{2}$	=	.500		$\frac{1}{2}$	+	$\frac{1}{16}$	=	.5625
$\frac{3}{8}$	=	.375		$\frac{3}{8}$	+	$\frac{1}{16}$	=	.4375
$\frac{1}{4}$	=	.250		$\frac{1}{4}$	+	$\frac{1}{16}$	=	.3125
$\frac{1}{8}$	=	.125		$\frac{1}{8}$	+	$\frac{1}{16}$	=	.1875
$\frac{1}{16}$	=	.0625						

## MELTING-POINTS OF SOLIDS.

Cast-iron.....	3477°		Lead.....	600°
Wrought-iron. ....	3981°		Zinc.....	741°
Gold.....	2587°		Cadmium .....	602°
Silver.....	1250°		Saltpetre.....	600°
Steel.....	2501°		Tin.....	420°
Brass.....	1897°		Sulphur.....	225°
Copper.....	2550°		Potassium.....	135°
Glass.....	2377°		Antimony .....	951°
Platinum.....	3077°		Bismuth.....	476°

## STRENGTH OF MATERIALS.

Tensile or breaking strength is the ability of the metal to resist a force tending to pull it apart.

Elastic resistance is the tendency of the metal to return back to its original shape and dimensions.

## RELATIVE STIFFNESS OF MATERIALS TO RESIST A TRANSVERSE STRAIN.

Ash.....	.089		Oak.....	.095
Beech.....	.072		White Pine.....	.1
Cast-iron.....	.1.		Wrought-iron.....	1.3
Elm.....	.073		Yellow Pine.....	.087



WEIGHT OF CAST-IRON PIPES PER LINEAL FOOT  
FROM 2 INCHES TO 10 FEET CORE.

The Diameter of Core is given in Inches and the weight of One Lineal Foot in Lbs.

Dia.	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$
2	5.51	8.71	12.25	16.07	20.2	25	30	35
$2\frac{1}{4}$	6.12	9.65	13.47	17.61	23	27	32	38
$2\frac{1}{2}$	6.73	10.57	14.7	19.13	24	29	35	40
$2\frac{3}{4}$	7.35	11.47	15.92	20.67	26	32	37	43
3	7.96	12.41	17.15	22.2	28	34	40	46
$3\frac{1}{4}$	8.57	13.32	18.37	24	30	36	42	49
$3\frac{1}{2}$	9.18	14.25	19.6	26	32	38	45	51
$3\frac{3}{4}$	9.8	15.15	21	27	34	40	47	54
4	10.41	16.07	23	29	35	42	50	57
$4\frac{1}{4}$	11.02	17	24	30	37	44	52	60
$4\frac{1}{2}$	11.63	17.91	25	32	39	47	54	63
$4\frac{3}{4}$	12.25	19	26	33	41	49	57	65
5	12.86	20	26	35	43	51	59	68
$5\frac{1}{4}$	13.47	21	29	36	45	53	62	71
$5\frac{1}{2}$	14.08	22	30	38	46	55	64	74
$5\frac{3}{4}$	14.69	23	31	40	48	57	67	76
6	15.31	24	32	41	50	59	69	79
$6\frac{1}{4}$	16	25	34	43	52	62	72	82
$6\frac{1}{2}$	17	26	35	44	54	64	74	85
$6\frac{3}{4}$	18	27	36	46	56	66	76	87
7	18	28	37	47	57	68	79	90
$7\frac{1}{4}$	19	29	38	49	59	70	81	93
$7\frac{1}{2}$	19	29	40	50	61	72	84	96
$7\frac{3}{4}$	20	30	41	52	63	74	86	98
8	21	31	42	53	65	77	89	101
$8\frac{1}{4}$	21	32	43	55	67	79	91	104
$8\frac{1}{2}$	22	33	45	56	68	81	94	107
$8\frac{3}{4}$	23	34	46	58	70	83	96	109
9	23	35	47	59	72	85	99	112
$9\frac{1}{4}$	24	36	48	61	74	87	101	115
$9\frac{1}{2}$	24	37	50	63	76	89	103	118
$9\frac{3}{4}$	25	38	51	64	78	92	106	120
10	26	39	52	66	80	94	108	123
$10\frac{1}{4}$	26	40	53	67	81	96	111	126
$10\frac{1}{2}$	27	40	54	69	83	98	113	129
$10\frac{3}{4}$	27	41	56	70	85	100	116	131
11	28	42	57	72	87	102	118	134

Dia.	1 $\frac{1}{4}$	1 $\frac{3}{8}$	1 $\frac{1}{2}$	1 $\frac{5}{8}$	1 $\frac{3}{4}$	1 $\frac{7}{8}$	2	3
2	40	46	52	58	65	72	79	148
2 $\frac{1}{4}$	43	49	56	62	69	76	84	155
2 $\frac{1}{2}$	46	53	59	66	73	81	89	162
2 $\frac{3}{4}$	49	56	63	70	78	85	94	170
3	53	59	67	74	82	90	99	177
3 $\frac{1}{4}$	56	63	70	78	86	95	103	184
3 $\frac{1}{2}$	59	66	74	82	91	99	108	192
3 $\frac{3}{4}$	62	70	78	86	95	104	113	199
4	65	73	81	90	99	108	118	206
4 $\frac{1}{4}$	68	76	85	94	103	113	123	214
4 $\frac{1}{2}$	71	80	89	98	108	118	128	221
4 $\frac{3}{4}$	74	83	92	102	112	122	133	228
5	77	86	96	106	116	127	138	236
5 $\frac{1}{4}$	80	90	100	110	121	131	143	243
5 $\frac{1}{2}$	83	93	103	114	125	136	148	250
5 $\frac{3}{4}$	86	96	107	118	129	141	152	258
6	89	100	111	122	133	145	157	265
6 $\frac{1}{4}$	92	103	114	126	138	150	162	272
6 $\frac{1}{2}$	95	107	118	130	142	154	167	280
6 $\frac{3}{4}$	98	110	122	134	147	159	172	287
7	102	113	125	138	151	164	177	295
7 $\frac{1}{4}$	105	117	129	142	155	168	182	302
7 $\frac{1}{2}$	108	120	133	146	159	173	187	309
7 $\frac{3}{4}$	111	123	136	150	163	177	192	317
8	114	127	140	154	168	182	197	324
8 $\frac{1}{4}$	117	130	144	158	172	187	201	331
8 $\frac{1}{2}$	120	134	148	162	176	191	206	339
8 $\frac{3}{4}$	123	137	151	166	181	196	211	346
9	126	140	155	170	185	200	216	353
9 $\frac{1}{4}$	129	144	159	174	189	205	221	361
9 $\frac{1}{2}$	132	147	162	178	193	210	226	368
9 $\frac{3}{4}$	135	150	166	182	198	214	231	375
10	138	154	170	186	202	219	236	383
10 $\frac{1}{4}$	141	157	174	190	206	223	241	390
10 $\frac{1}{2}$	144	161	178	194	211	228	246	397
10 $\frac{3}{4}$	147	164	181	198	215	232	250	405
11	151	167	184	202	219	237	255	412

WEIGHT OF CAST-IRON PIPES—*Continued.*

Dia.	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2
$11\frac{1}{4}$	29	58	89	121	154	188	224	261
$11\frac{1}{2}$	29	59	91	123	157	192	228	266
$11\frac{3}{4}$	30	61	93	126	160	196	233	271
12	31	62	94	128	163	199	237	275
$12\frac{1}{4}$	32	63	96	131	166	203	241	280
$12\frac{1}{2}$	33	64	98	133	169	206	245	285
$12\frac{3}{4}$	33	66	100	136	172	210	249	290
13	34	67	102	138	175	214	253	295
$13\frac{1}{4}$	34	68	103	140	178	217	258	299
$13\frac{1}{2}$	35	69	105	143	181	221	262	304
$13\frac{3}{4}$	35	70	107	145	184	225	266	309
14	36	72	109	148	187	228	271	314
$14\frac{1}{4}$	37	73	111	150	190	232	275	319
$14\frac{1}{2}$	37	74	113	152	193	236	279	324
$14\frac{3}{4}$	38	75	114	155	197	239	283	329
15	38	76	116	157	200	243	288	334
$15\frac{1}{4}$	39	78	118	160	203	247	292	339
$15\frac{1}{2}$	40	79	120	162	206	250	296	344
$15\frac{3}{4}$	41	80	122	165	209	254	301	348
16	42	81	124	167	212	258	305	353
$16\frac{1}{4}$	41	83	125	170	215	261	309	358
$16\frac{1}{2}$	42	84	127	172	218	265	314	363
$16\frac{3}{4}$	42	85	129	174	221	269	318	368
17	43	86	131	177	224	272	322	373
$17\frac{1}{4}$	43	87	133	179	227	276	326	378
$17\frac{1}{2}$	44	89	135	182	230	280	330	383
$17\frac{3}{4}$	45	90	136	184	233	283	335	388
18	46	91	138	187	236	287	339	393
$18\frac{1}{4}$	46	94	142	192	242	295	348	402
19	48	96	146	197	249	302	356	412
$19\frac{1}{4}$	49	99	149	201	255	309	365	422
20	50	101	153	206	261	317	374	432
$20\frac{1}{2}$	51	103	157	211	267	324	382	442
21	53	106	160	216	273	331	391	451
$21\frac{1}{2}$	54	108	164	221	279	339	399	461
22	55	111	168	226	285	346	408	471
$22\frac{1}{2}$	56	113	171	231	291	353	416	481
23	57	116	175	236	298	361	425	491
$23\frac{1}{2}$	59	118	179	241	304	368	434	500
24	60	121	182	246	310	375	442	510
25	62	125	190	255	322	390	459	530
26	65	130	197	265	334	405	476	549
27	67	135	204	275	345	419	494	569
28	69	140	212	285	359	434	511	589
29	72	145	219	295	371	450	528	608
30	75	150	227	304	383	464	545	628

WEIGHT OF CAST-IRON PIPES—*Continued.*

Dia.	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2
31	79	155	234	314	394	478	562	647
32	79	160	241	324	408	493	579	667
33	82	165	249	334	420	508	597	687
34	84	170	256	344	432	522	614	706
35	87	174	263	353	445	537	631	726
36	89	179	271	363	457	552	648	745
37	92	184	278	373	469	567	665	765
38	94	189	285	383	481	581	682	785
39	97	194	293	393	494	596	699	804
40	99	199	300	402	506	611	718	824
41	102	204	308	412	518	625	734	843
42	104	209	315	422	530	640	751	863
43	106	214	322	432	543	655	768	883
44	109	219	329	442	555	669	785	902
45	111	223	337	451	567	684	802	922
46	114	228	344	461	579	699	820	941
47	116	234	352	471	592	714	837	961
48	119	238	359	481	604	728	854	981
49	121	243	366	491	616	743	871	1000
50	124	248	374	500	628	758	888	1020
51	126	253	381	510	641	772	905	1039
52	129	258	388	520	653	787	922	1059
53	131	263	396	530	665	802	940	1079
54	133	268	403	540	678	816	957	1098
55	136	272	410	549	690	831	974	1118
56	138	278	418	559	702	846	991	1137
57	141	282	425	569	714	861	1008	1157
58	143	287	432	579	726	875	1025	1177
59	146	292	440	589	739	890	1043	1196
60	148	297	447	598	751	905	1060	1216
61	151	302	454	618	763	919	1077	1235
62	153	307	462	628	775	934	1095	1255
63	155	312	469	638	788	949	1111	1275
64	158	317	476	647	800	964	1128	1294
65	160	322	484	647	812	978	1145	1314
66	163	326	491	657	824	993	1163	1333
67	165	331	499	666	837	1008	1180	1353
68	168	336	506	677	849	1022	1197	1373
69	170	341	513	687	861	1037	1214	1392
70	173	346	521	696	873	1052	1231	1412
71	175	351	528	706	886	1066	1248	1432
72	178	356	535	716	898	1081	1266	1451
73	180	361	543	726	910	1096	1283	1471
74	182	365	550	736	922	1111	1304	1490
75	185	371	557	745	934	1125	1304	1510
76	187	375	565	755	947	1140	1317	1530

WEIGHT OF CAST-IRON PIPES—*Continued.*

Dia.	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2
77	190	380	572	765	959	1155	1334	1549
78	192	385	579	775	971	1169	1351	1569
79	195	390	587	785	984	1184	1368	1588
80	197	395	594	794	1000	1199	1386	1608
81	200	400	601	804	1008	1213	1403	1628
82	202	405	609	814	1020	1228	1419	1647
83	204	410	616	824	1033	1243	1437	1667
84	207	415	624	834	1045	1258	1454	1686
85	209	420	631	843	1057	1272	1489	1706
86	212	424	638	853	1069	1287	1506	1726
87	214	429	646	863	1082	1302	1523	1745
88	217	434	653	873	1094	1316	1540	1765
89	219	439	660	883	1106	1329	1557	1784
90	222	444	668	892	1119	1346	1574	1804
91	224	449	675	902	1131	1360	1591	1824
92	227	454	682	912	1143	1375	1609	1843
93	229	459	690	922	1155	1390	1626	1863
94	231	464	697	932	1167	1404	1643	1882
95	234	468	704	941	1180	1419	1660	1902
96	236	473	712	951	1192	1434	1677	1922
97	239	478	719	961	1204	1449	1694	1941
98	241	483	726	971	1217	1463	1711	1961
99	244	488	734	981	1229	1478	1729	1980
100	246	493	741	990	1241	1493	1746	2000
101	249	498	748	1000	1253	1508	1763	2020
102	251	503	756	1010	1266	1522	1780	2039
103	254	508	763	1020	1278	1537	1797	2059
104	256	513	771	1030	1290	1552	1814	2078
105	258	518	778	1039	1302	1566	1832	2098
106	261	522	785	1049	1315	1581	1849	2118
107	263	527	793	1059	1327	1596	1866	2137
108	266	532	799	1069	1339	1610	1883	2157
109	268	537	807	1079	1351	1625	1900	2176
110	271	542	815	1088	1364	1640	1917	2196
111	273	547	822	1098	1376	1655	1934	2216
112	276	552	829	1108	1388	1669	1952	2235
113	278	557	837	1118	1400	1684	1969	2255
114	280	562	844	1128	1413	1699	1986	2274
115	283	567	851	1137	1425	1713	2003	2294
116	285	571	859	1147	1437	1728	2020	2314
117	288	576	866	1157	1449	1743	2036	2333
118	290	581	873	1167	1462	1757	2055	2353
119	293	586	881	1177	1474	1772	2072	2373
120	295	591	888	1187	1486	1787	2089	2392

## WEIGHT PER LINEAL FOOT OF ROUND COLUMNS.

Columns in Inches and weight of One Lineal Foot in Lbs.

Dia.	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2
4	18	21	24	27	30								
5	23	27	32	36	40	43	46	49	52				
6	26	33	39	44	49	54	59	63	67	70	73	76	79
7	32	40	46	53	59	65	71	76	81	86	91	96	100
8	37	46	54	62	69	76	83	99	96	102	108	114	120
9	42	52	61	70	79	87	95	103	111	118	125	132	138
10	47	58	68	79	89	98	108	117	125	134	142	150	157
11	52	64	76	87	99	109	120	130	140	150	159	168	177
12	57	70	83	96	108	120	132	144	155	166	176	187	197
13	62	76	91	105	118	131	144	157	170	182	193	205	216
14	67	83	100	115	128	143	157	170	184	198	211	224	236
15	72	89	105	122	138	154	169	184	199	214	228	242	255
16	76	95	113	131	148	164	181	197	214	230	245	260	275
17	81	100	120	138	157	175	193	210	228	245	262	279	295
18	86	106	127	147	167	186	206	225	243	261	279	297	314
19	91	113	135	156	177	197	218	238	258	277	296	315	334
20	96	119	142	165	187	208	230	251	272	293	314	334	353
21	101	125	149	173	197	220	242	264	287	309	330	352	373
22	106	132	157	182	206	231	255	278	302	325	348	371	393
23	111	138	164	190	216	242	267	292	317	341	365	389	412
24	116	148	171	198	226	253	279	305	331	357	382	407	432

## WEIGHT OF CASTINGS FROM PATTERNS.

A Pattern, weighing One Pound, made of—	will weigh, when cast, in				
	Cast-iron.	Zinc.	Copper	Yellow Brass.	Gun-metal.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Mahogany, Nassau....	10.7	10.4	12.8	12.2	12.5
“ Honduras.	12.9	12.7	15.3	14.6	15
“ Spanish....	8.5	8.2	10.1	9.7	9.9
Pine, Red....	12.5	12.1	14.9	14.2	14.6
“ White.....	16.7	16.1	19.8	19	19.5
“ Yellow.....	14.1	13.6	16.7	16	16.5
Oak.....	9	8.6	10.4	10.1	10.9

WEIGHT OF SQUARE COLUMNS.

No. of Inches contained in End Section of Column.

20	24	28	32	36	40	44	48	52	56	60	64
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Weight of One Foot in Length, One Inch Thick, in Pounds.

63	75	87	100	113	125	138	150	163	174	187	200
----	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Dimensions of Columns in Inches.

6x6	7x7	8x8	9x9	10x10	11x11	12x12	13x13	14x14	15x15	16x16	17x17
7x5	8x6	9x7	10x8	11x 9	12x10	13x11	14x12	15x13	16x14	17x15	18x16
8x4	9x5	10x6	11x7	12x 8	13x 9	14x10	15x11	16x12	17x13	18x14	19x15
9x3	10x4	11x5	12x6	13x 7	14x 8	15x 9	16x10	17x11	18x12	19x13	20x14
	11x3	12x4	13x5	14x 6	15x 7	16x 8	17x 9	18x10	19x11	20x12	21x13
		13x3	14x4	15x 5	16x 6	17x 7	18x 8	19x 9	20x10	21x11	22x12
			15x3	16x 4	17x 5	18x 6	19x 7	20x 8	21x 9	22x10	23x11
				17x 3	18x 4	19x 5	20x 6	21x 7	22x 8	23x 9	24x10
					19x 3	20x 4	21x 5	22x 6	23x 7	24x 8	25x 9
						21x 3	22x 4	23x 5	24x 6	25x 7	26x 8
							23x 3	24x 4	25x 5	26x 6	27x 7
								25x 3	26x 4	27x 5	28x 6
									27x 3	28x 4	29x 5
										29x 3	30x 4
											31x 3

No. of Inches contained in End Section of Column.

68	72	76	80	84	88	92	96	100
----	----	----	----	----	----	----	----	-----

Weight of One Foot in Length, One Inch Thick, in Pounds.

213	225	238	250	263	275	288	300	313
-----	-----	-----	-----	-----	-----	-----	-----	-----

Dimensions of Columns in Inches.

18x18	19x19	20x20	21x21	22x22	23x23	24x24	25x25	26x26
19x17	20x18	21x19	22x20	23x21	24x22	25x23	26x24	27x25
20x16	21x17	22x18	23x19	24x20	25x21	26x22	27x23	28x24
21x15	22x16	23x17	24x18	25x19	26x20	27x21	28x22	29x23
22x14	23x15	24x16	25x17	26x18	27x19	28x20	29x21	30x22
23x13	24x14	25x15	26x16	27x17	28x18	29x19	30x20	31x21
24x12	25x13	26x14	27x15	28x16	29x17	30x18	31x19	32x20
25x11	26x12	27x13	28x14	29x15	30x16	31x17	32x18	33x19
26x10	27x11	28x12	29x13	30x14	31x15	32x16	33x17	34x18
27x 9	28x10	29x11	30x12	31x13	32x14	33x15	34x16	35x17
28x 8	29x 9	30x10	31x11	32x12	33x13	34x14	35x15	36x16
29x 7	30x 8	31x 9	32x10	33x11	34x12	35x13	36x14	37x15
30x 6	31x 7	32x 8	33x 9	34x10	35x11	36x12	37x13	38x14
31x 5	32x 6	33x 7	34x 8	35x 9	36x10	37x11	38x12	39x13
32x 4	33x 5	34x 6	35x 7	36x 8	37x 9	38x10	39x11	40x12
33x 3	34x 4	35x 5	36x 6	37x 7	38x 8	39x 9	40x10	41x11
	35x 3	36x 4	37x 5	38x 6	39x 7	40x 8	41x 9	42x10
		37x 3	38x 4	39x 5	40x 6	41x 7	42x 8	43x 9
			39x 3	40x 4	41x 5	42x 6	43x 7	44x 8

[illegible]



WEIGHT OF SQUARE PLATES ONE INCH THICK.

Inches square.	Pounds Weight.	Inches square.	Pounds Weight.	Inches square.	Pounds Weight.	Inches square.	Pounds Weight.
12	371½	46	552	80	1668	114	3388
13	44	47	576	81	1711	115	3448
14	51	48	601	82	1753	116	3508
15	58½	49	626	83	1796	117	3569
16	66½	50	652	84	1839	118	3630
17	75	51	678	85	1884	119	3692
18	84	52	705	86	1928	120	3754
19	95	53	732	87	1973	121	3817
20	104	54	760	88	2019	122	3880
21	115	55	789	89	2065	123	3944
22	126	56	818	90	2112	124	4009
23	138	57	847	91	2159	125	4073
24	150	58	876	92	2207	126	4139
25	163	59	907	93	2255	127	4205
26	176	60	939	94	2304	128	4271
27	190	61	970	95	2353	129	4338
28	204	62	1002	96	2403	130	4406
29	219	63	1035	97	2453	131	4474
30	235	64	1068	98	2504	132	4542
31	251	65	1101	99	2555	133	4612
32	267	66	1136	100	2607	134	4681
33	284	67	1170	101	2659	135	4751
34	301	68	1205	102	2712	136	4822
35	319	69	1241	103	2766	137	4893
36	338	70	1277	104	2820	138	4965
37	357	71	1314	105	2874	139	5037
38	376	72	1352	106	2929	140	5110
39	397	73	1389	107	2985	141	5183
40	417	74	1428	108	3041	142	5257
41	438	75	1467	109	3097	143	5331
42	459	76	1506	110	3154	144	5406
43	482	77	1546	111	3212		
44	505	78	1586	112	3270		
45	528	79	1627	113	3329		

WEIGHT OF A SUPERFICIAL SQUARE FOOT IN POUNDS  
FROM  $\frac{1}{16}$  INCH TO 3 INCHES.

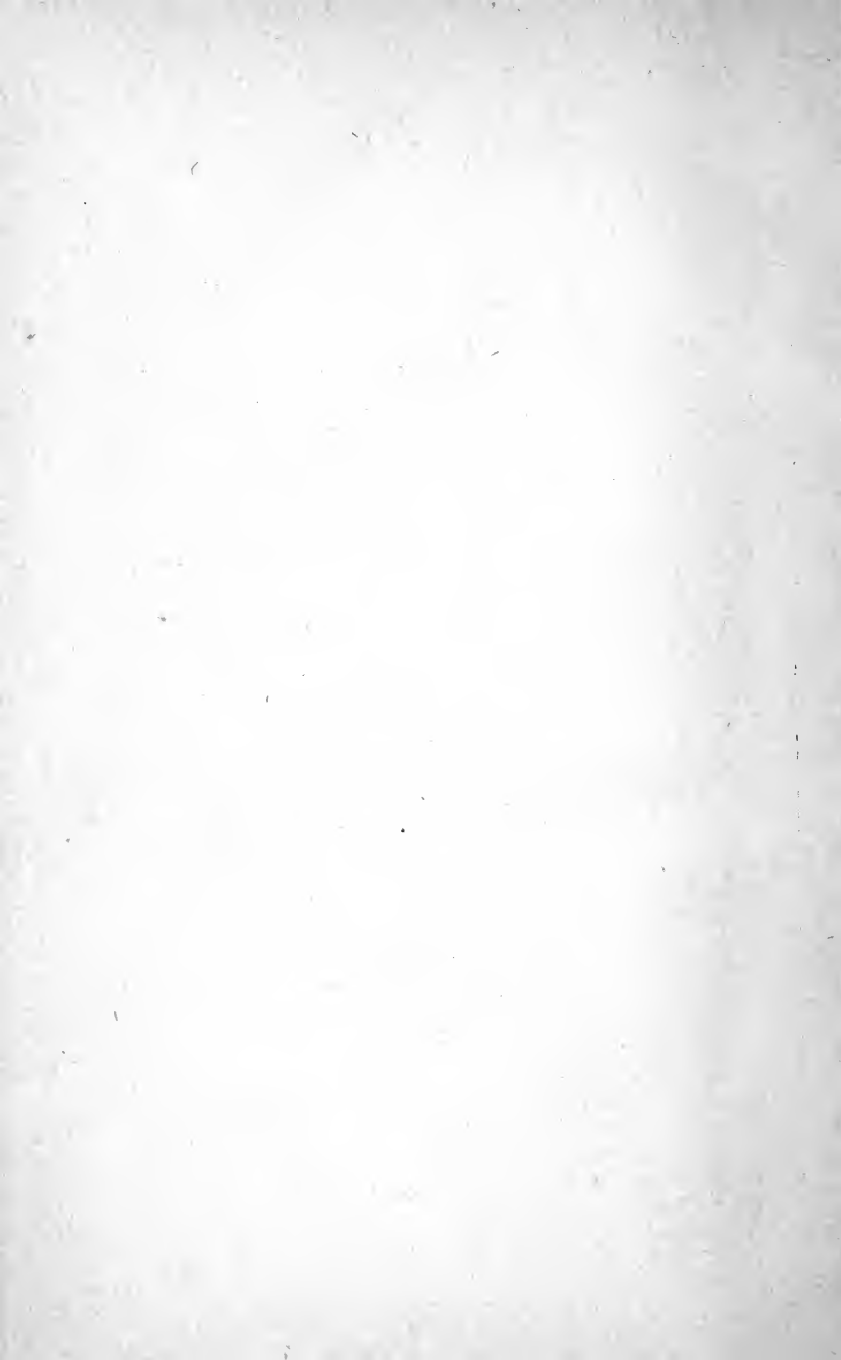
Thick- ness.	Cast- iron.	Wrought- iron.	Brass.	Copper.	Tin.	Steel.	Lead.
$\frac{1}{16}$	2.34	2.52	2.7	2.88	2.35	2.59	3.69
$\frac{1}{8}$	4.68	5.04	5.4	5.76	4.71	5.18	7.38
$\frac{1}{4}$	9.36	10.08	10.8	11.52	9.43	10.36	14.76
$\frac{3}{8}$	14.04	15.12	16.2	17.28	14.14	15.55	22.14
$\frac{1}{2}$	18.72	20.16	21.6	23.04	18.86	20.73	29.52
$\frac{5}{8}$	23.40	25.20	27.0	28.80	23.58	25.92	36.92
$\frac{3}{4}$	28.08	30.24	32.4	34.56	28.29	31.10	44.28
$\frac{7}{8}$	32.76	35.28	37.8	40.32	33.01	36.28	51.66
1	37.44	40.32	43.2	46.08	37.72	41.47	59.04
$1\frac{1}{8}$	42.12	45.36	48.6	51.84	42.44	46.65	66.42
$1\frac{1}{4}$	46.80	50.40	54.0	57.60	47.16	51.84	73.80
$1\frac{3}{8}$	51.48	55.44	59.4	63.36	51.87	57.02	81.08
$1\frac{1}{2}$	56.16	60.48	64.8	69.12	56.59	62.20	88.56
$1\frac{5}{8}$	60.84	65.52	70.2	74.88	61.30	67.39	95.94
$1\frac{3}{4}$	65.52	70.56	75.6	80.64	66.02	72.57	103.32
$1\frac{7}{8}$	70.20	75.60	81.0	86.40	70.74	77.76	110.70
2	74.88	80.64	86.4	92.16	75.45	82.94	118.08
$2\frac{1}{4}$	84.24	90.72	97.2	103.68	84.88	93.31	132.84
$2\frac{1}{2}$	93.60	100.80	108.0	115.20	94.32	103.68	147.60
3	112.32	120.96	129.6	138.24	113.18	124.41	177.12

TABLE SHOWING THE WEIGHT OR PRESSURE A BEAM OF CAST IRON, 1 INCH IN BREADTH, WILL SUSTAIN, WITHOUT DESTROYING ITS ELASTIC FORCE, WHEN IT IS SUPPORTED AT EACH END AND LOADED IN THE MIDDLE OF ITS LENGTH, AND ALSO THE DEFLECTION IN THE MIDDLE WHICH THAT WEIGHT WILL PRODUCE.

By MR. HODGKINSON, MANCHESTER, ENG.

Length	6 feet.		7 feet.		8 feet.		9 feet.		10 feet.	
Depth in ins.	Weight in lbs.	Deflec. in in.	Weight in lbs.	Deflec. in in.	Weight in lbs.	Deflec. in in.	Weight in lbs.	Deflec. in in.	Weight in lbs.	Deflec. in in.
3	1,278	.24	1,089	.33	954	.426	855	.54	765	.66
3½	1,739	.205	1,482	.28	1,298	.365	1,164	.46	1,041	.57
4	2,272	.18	1,936	.245	1,700	.32	1,520	.405	1,360	.5
4½	2,875	.16	2,450	.217	2,146	.284	1,924	.36	1,721	.443
5	3,560	.144	3,050	.196	2,650	.256	2,375	.32	2,125	.4
6	5,112	.12	4,356	.163	3,816	.213	3,420	.27	3,060	.33
7	6,958	.103	5,929	.14	5,194	.183	4,655	.23	4,165	.29
8	9,088	.09	7,744	.123	6,784	.16	6,080	.203	5,440	.25
9			9,801	.109	8,586	.142	7,695	.18	6,885	.22
10			12,100	.098	10,600	.128	9,500	.162	8,500	.2
11					12,826	.117	11,495	.15	10,285	.182
12					15,264	.107	13,680	.135	12,240	.17
13							16,100	.125	14,400	.154
14							18,600	.115	16,700	.143
	12 feet.		14 feet.		16 feet.		18 feet.		20 feet.	
6	2,548	.48	2,184	.65	1,912	.85	1,699	1.08	1,530	1.34
7	3,471	.41	2,975	.58	2,603	.73	2,314	.93	2,082	1.14
8	4,532	.36	3,884	.49	3,396	.64	3,020	.81	2,720	1.00
9	5,733	.32	4,914	.44	4,302	.57	3,825	.72	3,438	.89
10	7,083	.28	6,071	.39	5,312	.51	4,722	.64	4,250	.8
11	8,570	.26	7,346	.36	6,428	.47	5,714	.59	5,142	.73
12	10,192	.24	8,736	.33	7,648	.43	6,796	.54	6,120	.67
13	11,971	.22	10,260	.31	8,978	.39	7,980	.49	7,182	.61
14	13,883	.21	11,900	.28	10,412	.36	9,255	.46	8,330	.57
15	15,937	.19	13,660	.26	11,952	.34	10,624	.43	9,562	.53
16	18,128	.18	15,536	.24	13,584	.32	12,080	.40	10,880	.5
17	20,500	.17	17,500	.23	15,353	.30	13,647	.38	12,282	.47
18	22,932	.16	19,656	.21	17,208	.28	15,700	.36	13,752	.44

NOTE.—This table shows the greatest weight that ever ought to be laid upon a beam for permanent load; and if there be any liability to jerks, etc., ample allowance must be made; also the weight of the beam itself must be included.



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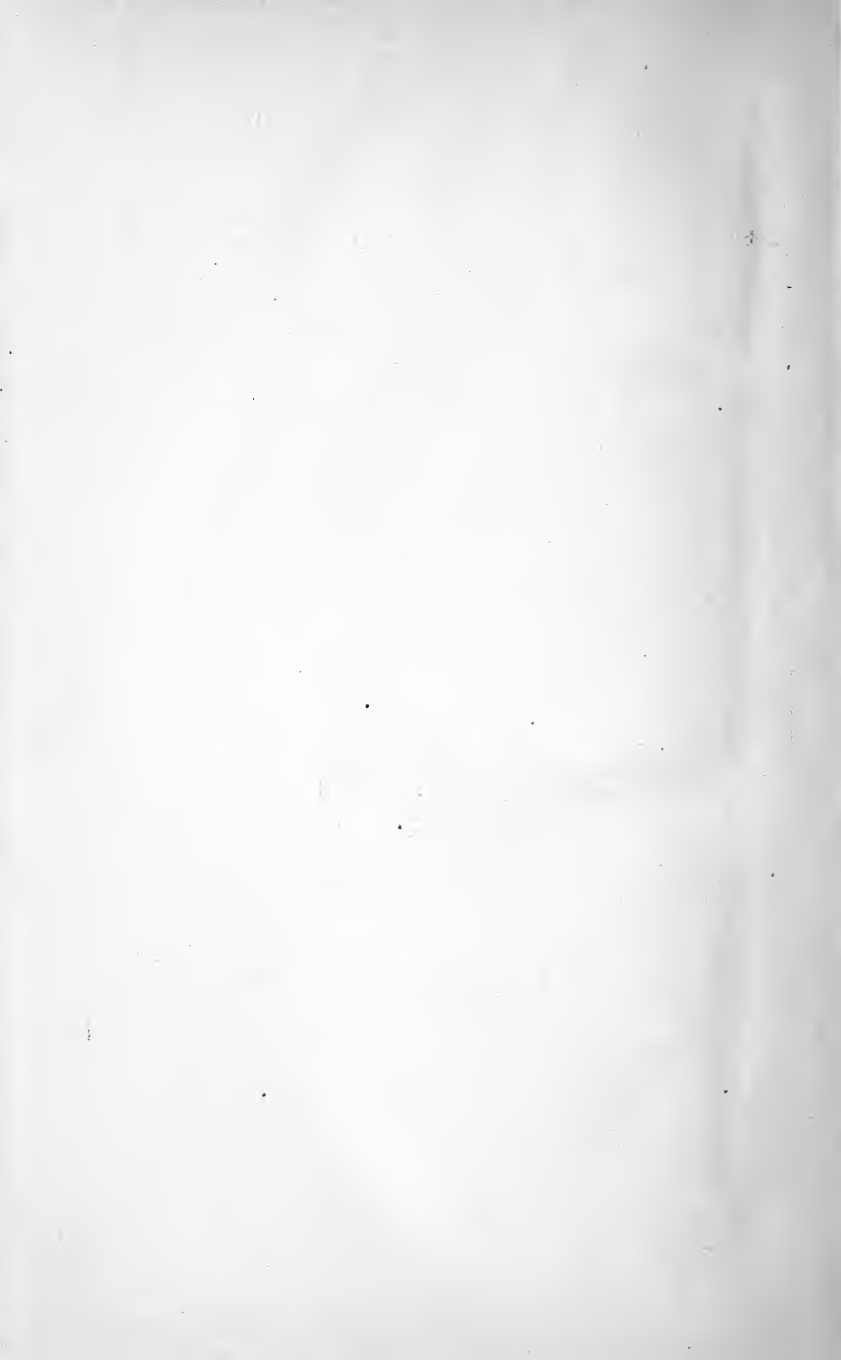
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